THE

POPULAR SCIENCE MONTHLY.

MAY, 1876.

SOCIETY AN ORGANISM.[1]

By HERBERT SPENCER.

THE question, What is a society? has to be asked and answered at the outset. Until we have decided whether or not to regard a society as an entity, and until we have decided whether, if regarded as an entity, a society is to be classed as absolutely unlike all other entities or as like some others, our conception of the subject-matter before us remains vague.

It may be said that a society is but a collective name for a number of individuals. Carrying the controversy between nominalism and realism into another sphere, a nominalist might affirm that, just as there exist only the members of a species, while the species considered apart from them has no existence, so the units of a society alone exist, while the existence of the society is but verbal. Instancing a lecturer's audience as an aggregate which, by disappearing at the close of the lecture, proves itself to be not a thing but only a certain arrangement of persons, he might argue that the like holds of the citizens forming a nation.

But, without disputing the other steps of his argument, the last step may be denied. The arrangement, temporary in one case, is lasting in the other; and it is the permanence of the relations among component parts which constitutes the individuality of a whole as distinguished from the individualities of its parts. A coherent mass broken into fragments ceases to be a thing; while, conversely, the stones, bricks, and wood, previously separate, become the thing called a house if connected in fixed ways.

Thus we consistently regard a society as an entity, because, though formed of discrete units, a certain concreteness in the aggregate of

[1] From advance-sheets of the "Principles of Sociology," Part II., "The Inductions of Sociology."

them is implied by the maintenance, for generations and centuries, of a general likeness of arrangement throughout the area occupied. And it is this trait which yields our idea of a society. For, withholding the name from an ever-changing cluster such as primitive men form, we apply it only where some constancy in the distribution of parts has resulted from settled life.

But now, regarding a society as a thing, what kind of a thing must we call it? It seems totally unlike every object with which our senses acquaint us. Any likeness it may possibly have to other objects cannot be manifest to perception, but can be discerned only by reason. If the constant relations among its parts make it an entity, the question arises whether these constant relations among its parts are akin to the constant relations among the parts of other entities. Between a society and anything else, the only conceivable resemblance must be one due to *parallelism of principle in the arrangement of components.*

There are two great classes of aggregates with which the social aggregate may be compared—the inorganic and the organic. Are the attributes of a society, considered apart from its living units, in any way like those of a not-living body? or are they in any way like those of a living body? or are they entirely unlike those of both?

The first of these questions needs only to be asked to be answered in the negative. A whole of which the parts are alive cannot, in its general characters, be like lifeless wholes. The second question, not to be thus promptly answered, is to be answered in the affirmative. The reasons for asserting that the permanent relations among the parts of a society are analogous to the permanent relations among the parts of a living body, we have now to consider.

When we say that growth is common to social aggregates and organic aggregates, we do not thus entirely exclude community with inorganic aggregates: some of these, as crystals, grow in a visible manner; and all of them, on the hypothesis of evolution, are concluded to have arisen by integration at some time or other. Nevertheless, compared with things we call inanimate, living bodies and societies so conspicuously exhibit augmentation of mass that we may fairly regard this as characteristic of them both. Many organisms grow throughout their lives, and the rest grow throughout considerable parts of their lives. Social growth usually continues either up to times when the societies divide, or up to times when they are overwhelmed.

Here, then, is the first trait by which societies ally themselves with the organic world, and substantially distinguish themselves from the inorganic world.

It is also a character of social bodies, as of living bodies, that while they increase in size they increase in structure. A low animal, or the embryo of a high one, has few distinguishable parts; but along

with its acquirement of greater mass its parts multiply and simultaneously differentiate. It is thus with a society. At first the unlikenesses among its groups of units are inconspicuous in number and degree; but, as it becomes more populous, divisions and subdivisions become more numerous and more decided. Further, in the social organism as in the individual organism, differentiations cease only with that completion of the type which marks maturity and precedes decay.

Though in inorganic aggregates also, as in the entire solar system and in each of its members, structural differentiations accompany the integrations, yet these are so relatively slow, and so relatively simple, that they may be disregarded. The multiplication of contrasted parts in bodies politic and in living bodies is so great that it substantially constitutes another common character which marks them off from inorganic bodies.

This community will be more fully appreciated on observing that progressive differentiation of structures is accompanied by progressive differentiation of functions.

The multiplying divisions, primary, secondary, and tertiary, which arise in a developing animal, do not assume their major and minor unlikenesses to no purpose. Along with diversities in their shapes and compositions there go diversities in the actions they perform: they grow into unlike organs having unlike duties. Assuming the entire function of absorbing nutriment at the same time that it takes on its structural characters, the alimentary system becomes gradually marked off into contrasted portions, each of which has a special function forming part of the general function. A limb, instrumental to locomotion or prehension, acquires divisions and subdivisions which perform their leading and their subsidiary shares in this office. So is it with the parts into which a society divides. A dominant class arising does not simply become unlike the rest, but assumes control over the rest; and when this class separates into the more and the less dominant, these, again, begin to discharge distinct parts of the entire control. With the classes whose actions are controlled it is the same. The various groups into which they fall have various occupations, each of such groups also, within itself, acquiring minor contrasts of parts along with minor contrasts of duties.

And here we see more clearly how the two classes of things we are comparing distinguish themselves from things of other classes; for such differences of structure as slowly arise in inorganic aggregates are not accompanied by what we can fairly call differences of function.

Why in a body politic and in a living body these unlike actions of unlike parts are properly regarded by us as functions, while we cannot so regard the unlike actions of unlike parts in an inorganic body, we shall perceive on turning to the next and most distinctive common trait.

Evolution establishes in them both, not differences simply, but definitely-connected differences—differences such that each makes the others possible. The parts of an inorganic aggregate are so related that one may change greatly without appreciably affecting the rest. It is otherwise with the parts of an organic aggregate or of a social aggregate. In either of these the changes in the parts are mutually determined, and the changed actions of the parts are mutually dependent. In both, too, this mutuality increases as the evolution advances. The lowest type of animal is all stomach, all respiratory surface, all limb. Development of a type having appendages by which to move about or lay hold of food can take place only if these appendages, losing power to absorb nutriment directly from surrounding bodies, are supplied with nutriment by parts which retain the power of absorption. A respiratory surface, to which the circulating fluids are brought to be aërated, can be formed only on condition that the concomitant loss of ability to supply itself with materials for repair and growth is made good by the development of a structure bringing these materials. So is it in a society. What we call with perfect propriety its organization has a necessary implication of the same kind. While rudimentary, it is all warrior, all hunter, all hut-builder, all tool-maker: every part fulfills for itself all needs. Progress to a stage characterized by a permanent army can go on only as there arise arrangements for supplying that army with food, clothes, and munitions of war, by the rest. If here the population occupies itself solely with agriculture and there with mining—if these manufacture goods while those distribute them—it must be on condition that, in exchange for a special kind of service rendered by each part to other parts, these other parts severally give due proportions of their services.

This division of labor, first dwelt on by political economists as a social phenomenon, and thereupon recognized by biologists as a phenomenon of living bodies, which they called the "physiological division of labor," is that which in the society, as in the animal, makes it a living whole. Scarcely can I emphasize sufficiently the truth that, in respect of this fundamental trait, a social organism and an individual organism are entirely alike. When we see that, in a mammal, arresting the lungs quickly brings the heart to a stand; that if the stomach fails absolutely in its office all other parts by-and-by cease to act; that paralysis of its limbs entails on the body at large death from want of food or inability to escape; that loss of even such small organs as the eyes deprives the rest of a service essential to their preservation—we cannot but admit that mutual dependence of parts is an essential characteristic. And when, in a society, we see that the workers in iron stop if the miners do not supply materials; that makers of clothes cannot carry on their business in the absence of those who spin and weave textile fabrics; that the manufacturing community will cease to act unless the food-producing and food-dis-

tributing agencies are acting; that the controlling powers, governments, bureaus, judicial officers, police, must fail to keep order when the necessaries of life are not supplied to them by the parts kept in order—we are obliged to say that this mutual dependence of parts is similarly rigorous. Unlike as the two kinds of aggregates are in sundry respects, they are alike in respect of this fundamental character, and the characters implied by it.

How the combined actions of mutually-dependent parts constitute life of the whole, and how there hence results a parallelism between national life and individual life, we see still more clearly on learning that the life of every visible organism is constituted by the lives of units too minute to be seen by the unaided eye.

An undeniable illustration is furnished us by the strange order *Myxomycetes*. The spores or germs produced by one of these forms become ciliated monads which, after a time of active locomotion, change into shapes like those of amœbæ, move about, take in nutriment, grow, multiply by fission. Then these amœba-form individuals swarm together, begin to coalesce into groups, and these groups to coalesce with one another, making a mass sometimes barely visible, sometimes as big as the hand. This *plasmodium*, irregular, mostly reticulated, and in substance gelatinous, itself exhibits movements of its parts like those of a gigantic rhizopod, creeping slowly over surfaces of decaying matters and even up the stems of plants. Here, then, union of many minute living individuals to form a relatively vast aggregate in which their individualities are apparently lost, but the life of which results from combination of their lives, is demonstrable.

In other cases, instead of units which, originally discrete, lose their individualities by aggregation, we have units which, arising by multiplication from the same germ, do not part company, but nevertheless display their separate lives very clearly. A growing sponge has its horny fibres clothed with a gelatinous substance, and the microscope shows this to consist of moving monads. We cannot deny life to the sponge as a whole, for it shows us some corporate actions. The outer amœba-form units partially lose their individualities by fusion into a protective layer or skin; the supporting framework of fibres is produced by the joint agency of the monads, and from their joint agency also result those currents of water which are drawn in through the small orifices and expelled through the larger. But, while there is thus shown a feeble aggregate life, the lives of the myriads of component units are very little subordinated: these units form, as it were, a nation having scarcely any subdivision of functions. Or, in the words of Prof. Huxley, "the sponge represents a kind of subaqueous city, where the people are arranged about the streets and roads in such a manner that each can easily appropriate his food from the water as it passes along."

Even in the highest animals there remains traceable this relation between the aggregate life and the lives of components. Blood is a liquid in which, along with nutritive matters, circulate innumerable living units—the blood-corpuscles. These have severally their life-histories. During its first stage each of them, then known as a white corpuscle, makes independent movements like those of an amœba; and though in its adult stage, as a red, flattened disk, it is not visibly active, its individual life continues. Nor is this individual life of the units provable only where free flotation in a liquid allows its signs to be readily seen. Sundry mucous surfaces, as those of the air-passages, are covered with what is called ciliated epithelium—a layer of minute cells packed side by side, and each bearing on its exposed end several cilia continually in motion. The wavings of these cilia are essentially like those of the monads which live in the passages running through a sponge; and just as the joint action of these ciliated sponge monads propels the current of water, so does the joint action of the ciliated epithelium-cells move forward the mucous secretion covering them. If there needs further proof of the individual lives of these epithelium-cells, we have it in the fact that, when detached and placed in fluid, they "move about with considerable rapidity for some time, by the continued vibrations of the cilia with which they are furnished."

On thus seeing that an ordinary living organism may be regarded as a nation of units that live individually, and have many of them considerable degrees of independence, we shall perceive how truly a nation of human beings may be regarded as an organism.

The relation between the lives of the units and the life of the aggregate has a further character common to the two cases. By a catastrophe the life of the aggregate may be destroyed without immediately destroying the lives of all its units; while, on the other hand, if no catastrophe abridges it, the life of the aggregate immensely exceeds in length the lives of its units.

In a cold-blooded animal, ciliated cells perform their motions with perfect regularity long after the creature they are part of has become motionless; muscular fibres retain their power of contracting under stimulation; the cells of secreting organs go on pouring out their product if blood is artificially supplied to them; and the components of an entire organ, as the heart, continue their coöperation for many hours after its detachment. Similarly, arrest of those commercial activities and governmental coördinations, etc., which constitute the corporate life of a nation, may be caused, say by an inroad of barbarians, without immediately stopping the actions of all the units. Certain classes of these, especially the widely-diffused ones engaged in food-production, may, in the remoter districts, long survive and carry on their individual occupations.

Conversely, in both cases, if not brought to a close by violence,

the life of the aggregate greatly exceeds in duration the lives of its units. The minute living elements composing a developed animal severally evolve, play their parts, decay, and are replaced, while the animal as a whole continues. In the deep layer of the skin, cells are formed by fission, which, as they enlarge, are thrust outward, and, becoming flattened to form the epidermis, eventually exfoliate, while the younger ones beneath take their places. Liver-cells, growing by imbibition of matters from which they separate the bile, presently die, and their vacant seats are occupied by another generation. Even bone, though so dense and seemingly inert, is permeated by blood-vessels carrying materials to replace old components by new ones. And the replacement, rapid in some tissues and in others slow, goes on at such rate that, during the continued existence of the entire body, each portion of it has been many times over produced and destroyed. Thus it is also with a society and its units. Integrity of the whole and of each large division is perennially maintained, notwithstanding the deaths of component citizens. The fabric of living persons, which, in a manufacturing town, produces some commodity for national use, remains after a century as large a fabric, though all the masters and workers who a century ago composed it have long since disappeared. Even with the minor parts of this industrial structure the like holds. A firm that dates from past generations, still carrying on business in the name of its founder, has had all its members and employés changed one by one, perhaps several times over, while the firm has continued to occupy the same place and to maintain like relations to buyers and sellers. Throughout we find this. Governing bodies, general and local, ecclesiastical corporations, armies, institutions of all orders down to guilds, clubs, philanthropic associations, etc., show us a continuity of life exceeding that of the persons constituting them. Nay, more. As part of the same law, we see that the existence of the society at large exceeds in duration that of some of these compound parts. Private unions, local public bodies, secondary national institutions, towns carrying on special industries, may decay, while the nation, maintaining its integrity, evolves in mass and structure.

In both cases, too, the mutually-dependent functions of the various divisions, being severally made up of the actions of many units, it results that these units, dying one by one, are replaced without the function in which they share being sensibly affected. In a muscle each sarcous element wearing out in its turn is removed, and a substitution made while the rest carry on their combined contractions as usual; and the retirement of a public official or death of a shopman perturbs inappreciably the business of the department or activity of the industry in which he had a share.

Hence arises in the social organism, as in the individual organism, a life of the whole quite unlike the lives of the units, though it is a life produced by them.

From these likenesses between the social organism and the individual organism, we must now turn to an extreme unlikeness. The parts of an animal form a concrete whole, but the parts of a society form a whole that is discrete. While the living units composing the one are bound together in close contact, the living units composing the other are free, not in contact, and more or less widely dispersed. How, then, can there be any parallelism?

Though this difference is fundamental and apparently puts comparison out of the question, yet examination proves it to be less than it seems. Presently I shall have to point out that complete admission of it consists with maintenance of the alleged analogy; but we will first observe how one who thought it needful might argue that even in this respect there is more kinship than a cursory glance shows.

He might urge that the physically-coherent body of an animal is not composed all through of living units, but that it consists in large measure of differentiated parts which the vitally active parts have formed, and which thereafter become semi-vital and in some cases almost un-vital. Taking as an example the protoplasmic layer underlying the skin, he might say that, while this consists of truly living units, the cells produced in it, changing into epithelium-scales, become inert protective structures; and, pointing to the insensitive nails, hair, horns, and teeth, arising from this layer, he might show that such parts, though components of the organism, are hardly living components. Carrying out the argument, he would contend that elsewhere in the body there exist such protoplasmic layers, from which grow the tissues composing the various organs—layers which alone remain fully alive, while the structures evolved from them lose their vitality in proportion as they are specialized: instancing cartilage, tendon, and connective tissue, as showing in conspicuous ways this low vitality. From all which he would draw the inference that, though the body forms a coherent whole, its essential units, taken by themselves, form a whole which is coherent only throughout the protoplasmic layers.

And then would follow the argument that the social organism, rightly conceived, is much less discontinuous than it seems. He would contend that, as in the individual organism we include with the fully living parts the less living and not living parts which cooperate in the total activities, so, in the social organism, we must include not only those most highly-vitalized units, the human beings, who chiefly determine its phenomena, but also the various kinds of domestic animals, lower in the scale of life, which under the control of man coöperate with him, and even those far inferior structures the plants, which, propagated by human agency, supply materials for animal and human activities. In defense of this view he would point out how largely these lower classes of organisms, coexisting with men in societies, affect the structures and activities of the societies—how

the traits of the pastoral type depend on the natures of the creatures reared; and how, in settled societies, the plants producing food, materials for textile fabrics, etc., determine certain kinds of social arrangements and actions. After which he might insist that, since the physical characters, mental natures, and daily activities, of the human units are in part moulded by relations to these animals and vegetables which, living by their aid, and aiding them to live, enter so much into social life as even to be cared for by legislation, these lower living things cannot rightly be excluded from the conception of the social organism. Hence would come his conclusion that when, with human beings, are incorporated the less vitalized beings, animal and vegetal, covering the surface occupied by the society, an aggregate results having a continuity of parts, more nearly approaching to that of an individual organism, and which is also like it in being composed of local aggregations of highly-vitalized units, imbedded in a vast aggregation of units of various lower degrees of vitality, which are in a sense produced by, modified by, and arranged by, the higher units.

But without accepting this view, and admitting that the discreteness of the social organism stands in marked contrast with the concreteness of the individual organism, the objection may still be adequately met.

Though coherence among its parts is a prerequisite to that cooperation by which the life of an individual organism is carried on, and though the members of a social organism, not forming a concrete whole, cannot maintain coöperation by means of physical influences directly propagated from part to part, yet they can and do maintain coöperation by another agency. Not in contact, they nevertheless affect one another through intervening spaces, both by emotional language, and by the language, oral and written, of the intellect. For carrying on mutually dependent actions it is requisite that impulses, adjusted in their kinds, amounts, and times, shall be conveyed from part to part. This requisite is fulfilled in living bodies by molecular waves, that are indefinitely diffused in low types, and in high types are carried along definite channels (the function of which has been significantly called *internuncial*). It is fulfilled in societies by the signs of feelings and thoughts, conveyed from person to person; at first in vague ways and only at short distances, but afterward more definitely and at greater distances. That is to say, the internuncial function, not achievable by stimuli physically transferred, is nevertheless achieved by language.

The mutual dependence of parts which constitutes organization is thus effectually established. Though discrete instead of concrete, the social aggregate is rendered a living whole.

But now, on pursuing the course of thought opened by this objection and the answer to it, we arrive at an implied contrast of great

significance—a contrast fundamentally affecting our idea of the ends to be achieved by social life.

Though the discreteness of a social organism does not prevent subdivision of functions and mutual dependence of parts, yet it does prevent that differentiation by which one part becomes an organ of feeling and thought, while other parts become insensitive. High animals, of whatever class, are distinguished from low ones by complex and well-integrated nervous systems. While in inferior types the minute scattered ganglia may be said to exist for the benefit of other structures, the concentrated ganglia in superior types are the structures for the benefit of which the rest may be said to exist. Though a developed nervous system so directs the actions of the whole body as to preserve its integrity, yet the welfare of the nervous system is the ultimate object of all these actions, damage to any other organ being serious only because it immediately or remotely entails that pain or loss of pleasure which the nervous system suffers. But the discreteness of a society negatives differentiations carried to this extreme. In an individual organism the minute living units, most of them permanently localized, growing up, working, reproducing, and dying away in their respective places, are in successive generations moulded to their respective functions, so that some become specially sentient and others entirely insentient. But it is otherwise in a social organism. The units of this, out of contact and much less rigidly held in their relative positions, cannot be so much differentiated as to become feelingless units and units which monopolize feeling. There are, indeed, slight traces of such a differentiation. Human beings are unlike in the amounts of sensation and emotion producible in them by like causes: here great callousness, here great susceptibility, is characteristic. In the same society, even where its members are of the same race, and still more where its members are of dominant and subject races, there exists a contrast of this kind. The mechanically-working and hard-living units are less sensitive than the mentally-working and more protected units. But while the regulative structures of the social organism tend, like those of the individual organism, to become seats of feeling, the tendency is checked by this want of physical cohesion which brings fixity of function; and it is also checked by the continued need for feeling in the mechanically-working units for the due discharge of their functions.

Hence, then, a cardinal difference in the two kinds of organisms. In the one, consciousness is concentrated in a small part of the aggregate. In the other, it is diffused throughout the aggregate: all the units possess the capacities for happiness and misery, if not in equal degrees, still in degrees that approximate. As, then, there is no social sensorium, it results that the welfare of the aggregate, considered apart from that of the units, is not an end to be sought. The society exists for the benefit of its members; not its members for the benefit

of the society. It has ever to be remembered that great as may be the efforts made for the prosperity of the body politic, yet the claims of the body politic are nothing in themselves, and become something only in so far as they embody the claims of its component individuals.

From this last consideration, which is a digression rather than a part of the argument, let us now return and sum up the various reasons for regarding a society as an organism.

It undergoes continuous growth; as it grows, its parts, becoming unlike, exhibit increase of structure; the unlike parts simultaneously assume activities of unlike kinds; these activities are not simply different, but their differences are so related as to make one another possible; the reciprocal aid thus given causes mutual dependence of the parts; and the mutually-dependent parts, living by and for one another, form an aggregate constituted on the same general principle as an individual organism. The analogy of a society to an organism becomes still clearer on learning that every organism of appreciable size is a society, and on further learning that, in both, the lives of the units continue for some time if the life of the aggregate is suddenly arrested, while if the aggregate is not destroyed by violence its life greatly exceeds in duration the lives of its units. Though the two are contrasted as respectively discrete and concrete, and though there results a difference in the ends subserved by the organization, there does not result a difference in the laws of the organization: the required mutual influences of the parts, not transmissible in a direct way, being transmitted in an indirect way.

Having thus considered in their most general forms the reasons for regarding a society as an organism, we are prepared for following out the comparison in detail. We shall find that the further we pursue it the closer does the analogy appear.

HAMMERS AND PERCUSSION.

By the Rev. ARTHUR RIGG, M. A.

THE only mechanical tools for external use with which man is provided by Nature are: the hammer, a compound vise, and a scratching or scraping tool; these are all in the hand. As a vise, the hand is worthy of a very lengthened notice; as a hammer alone it is now our concern. While upon a substance softer than itself the fist can deal an appreciable blow, with one harder than itself the reaction of the substance transfers the blow to the flesh and bone of Nature's hammer. Hence early arose the necessity of an artificial hammer of stone or other hard substance.

[1] Abstract of three lectures before the London Society of Arts.

Among the contrivances which have come down to us from the ages before history was written, or the use of metals known, are found stones shaped, as we may suppose, by the action of water, and so rounded as to fit the hand. These stones are called by antiquarians "mauls," and they were probably held in the hand and struck against objects which otherwise could not have been broken. The maul is the original form of the hammer. This maul might occasionally have proved too heavy, but more frequently too light. For that tapping action which in our minor wants is often more requisite than blows, our prehistoric ancestors seem to have devised an ingenious appliance consisting of a stone specially prepared for this somewhat delicate operation. (Fig. 1.)

FIG. 1.—TAPPING-HAMMER OF STONE.

This is supposed to be one of these tapping-hammers, held between a finger and the thumb; the original bears traces of wear, as if it had been employed in striking against a cylindrical or sharp surface.

When, now, we pass from this light to very heavy work, it will be obvious that to hold a stone in the hollow of the hand, and to strike an object with it so that the reaction of the blow shall be mainly met by the muscular action of the back of the hand, and the thinnest section of the wrist, would be not only fatiguing, but might be injurious to the delicate network of muscles there found, and so damage this part of the hand. It may have been from such effects that even in the Stone age there are traces of mauls which have double ends and are held by the middle. A blow given by such is counteracted not only by the increased mass of material, but also by the changed position of the hand and wrist in relation to the direction of the blow. When held in the hollow of the hand, the reaction was met by (say) a depth of tissue of about three-quarters of an inch, but, when held as the maul now alluded to must have been held, this reaction is met by a depth of tissue of about three inches. Hence, while mechanically (owing to the mass of stone) and muscularly (owing to the position of the hand in reference to the direction of the blow) the maul in this second stage is a decided improvement upon its primitive form, we cannot but admit that experience would soon suggest that even thus there was wanting sufficient energy to overcome reactions, and that the double-headed maul might be improved.

The men of the Stone age early perceived the advantage of having a handle of some kind for their mauls, and doubtless their first expedient consisted in lashing withes around such mauls as were found suitable, as the blacksmith at the present day lashes withes round the heads of his cutting and punching tools and swages. Evidences of a further advance toward a perfect hammer are to be seen in stone mauls with holes through them suitable for handles; and these holes are in some instances coned, and as well adapted for hammer-handles as the best-made metal tools of our day.

FIG. 2.—PERFORATED HAMMER-HEAD OF STONE.

Before inquiring into the reasons which may have led to the adoption of the various materials and forms of hammers now in use, it will be well to consider the hammer in, and of, and by itself. We are so apt to look upon it as a rude implement, necessarily associated with a superior class of finishing-tools, that the materials, forms, and scientific principles involved in its construction and use, not only as an adjunct to other tools, but as a sole independent and final tool, are much overlooked.

In some handicrafts, and those too involving a high class of finished work, the hammer is the only tool employed. That great artistic

skill in the use of the hammer as a finishing-tool can be acquired, is manifest from the many beautiful specimens of *répoussé* work to be seen in silversmiths' shops. The details of the ornamentation are not only minute, but they so harmonize as to give elegance and expression to the whole, exclusive of the form of the articles themselves. The variety of shape is mainly produced by changes in the form of the "pane" of the hammer and in the weight of it. These changes of "pane" are sometimes effected by separating the pane from the hammer, and then the separated piece is called a "punch."

The famous shield of Achilles, in the "Iliad" of Homer, is described as the result of hammer-work; and, though this shield may not have been actually fashioned, nevertheless the description gives an idea of what a hammer was in early times poetically supposed to be capable of accomplishing. The scenes wrought upon the shield of Achilles are—1. The earth, sea, and heavenly bodies. 2. In a city at peace there are (*a.*) Marriage festivities; (*b.*) Judicial suit or trial. 3. In a city at war there are (*a.*) A scene before the ramparts; (*b.*) An ambush and surprise; (*c.*) A bloody fight. 4. The ploughing of a field. 5. The harvest and the meal in preparation. 6. The vintage, with music and a march. 7. A herd of cattle attacked by lions. 8. Sheep at pasture, and their folds. 9. A dance. 10. The great ocean-river encompassing the whole, as, in the mind of Homer, it encompassed the earth. For examples of the use of hammers in the production of works of great variety and extent on a large scale, see the ancient hammered wrought-iron gates, hinges, and panels, in the architectural room in the South Kensington Museum; also the suits of mail and chain-armor in the Tower of London; also the formation of gold-leaf, the springs of carriages, and the stiffening of saw-plates.

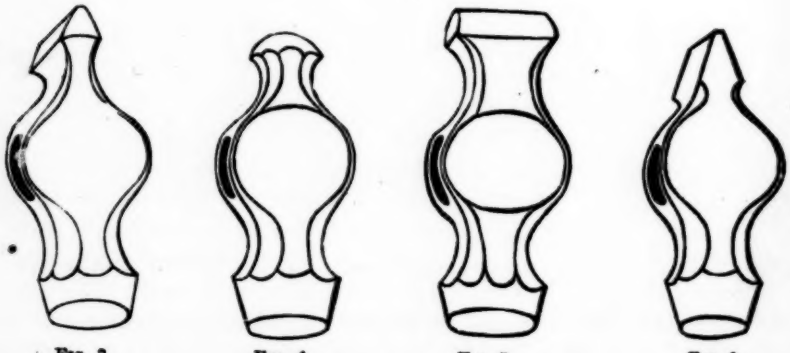


FIG. 3. FIG. 4. FIG. 5. FIG. 6.

ENGINEER'S HAMMERS.

The nature of the work to be done by hammers calls for very great differences, not only in the form, material, and weight of the hammer-head, but also in the appendages to these. There are the material

and form of the handles, the angle at which these handles should intersect the axial line of the hammer-head, the position of the centre of gravity with respect to the intersection of this axial line, the length and elasticity of the handle. If the centre of gravity is not in the central line or longitudinal axis of the hammer-head, then there is a tendency to bring the hammer down on the edge of the face and not on the face. If this defective construction were great, the muscles of the wrist might not be strong enough to counteract the tendency. If the defective construction is slight, then the work is often marked with angular indents. Arrangements, too, may be required for modifying the intensity of the blow, while retaining the effects resulting from a heavy hammer where a light one would be inefficient.

It is curious to see how in the same trade the hammers are for different purposes made of different materials. The engineer, for example, uses hammers faced with steel hardened, the stone-breaker (or mineralogist) hammers faced with steel softened (or rather not hardened). Again, in another part of his progressive work, the steel hammer with which the engineer commenced his operations gives place to a bronze or copper one, and this is sometimes displaced by one of lead alloyed with tin, and the handle entirely discarded.

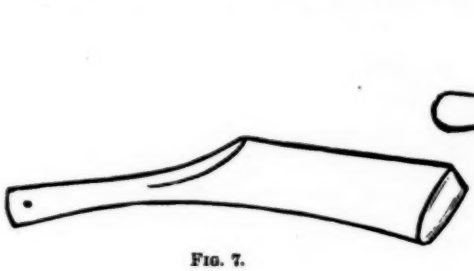


Fig. 7.

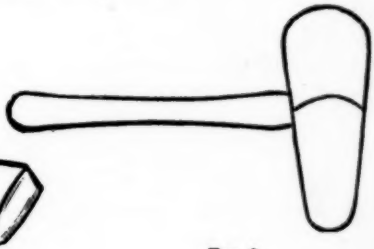


Fig. 8.

Fig. 9.

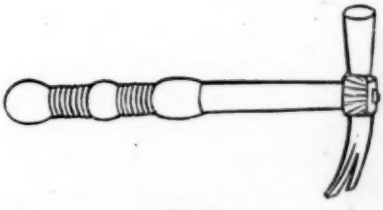


Fig. 10.

Plumber's Hammers.

The plumber dismisses all these, and for direct action upon the material employed in his trade he uses a hammer of wood, discarding not only the material but also the form of hammers used in allied crafts. Indeed, one of his hammers (Fig. 7) serves a double purpose, for, if at one moment it is a hammer, at the next it is used as a swage. Fig. 9 is his ordinary hammer, but when carrying on his allied trade of a glazier, not content with this, even the handle (Fig. 10) is finished

in an unusual manner, probably for convenience in holding putty, which he often carries "dabbed" on the handle. In some cases, as in the working of copper vessels which have been silver-plated or gilt, the coats of the precious metals are so thin that, although the weight of a hammer-head is required, yet even the wooden hammer of the plumber, or the still softer leaden hammer of the engineer, is equally unsuitable, and therefore the workers in these metals cover the face of their hammers at times with one or more layers of cloth.

The veneering hammer is compound, one end being formed of metal and the other of wood. The metal end is used as a squeezing-hammer (if such a term may be employed), and the wooden end as a tapping-hammer, to ascertain by the sound produced where the veneering is adhering and where it is not.

FIG. 11.—MASON'S HAMMER-HEAD.

The stone-mason seems to claim a universal choice. As to material, he has and frequently uses hammers made of wood, of iron (steel-faced), and of an alloy of lead.

In some cases the hammer and the anvil mutually change places, the hammer of wood, the anvil of metal, or the converse. Nor is the

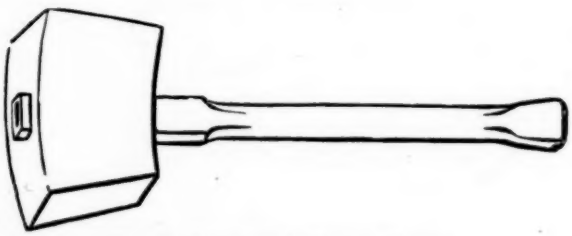
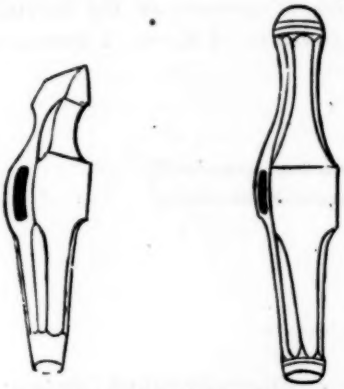


FIG. 12.—CARPENTER'S WOODEN MALLET.

wood always of the same character. As varied as are the characters of the woods themselves, so varied are those chosen by different crafts for the employment of each craft.

Hammers with and without handles are in use—hammers of various weights, from half an ounce to ten pounds, and from fifteen to fifty-six pounds are now employed as hand-hammers. The angles of attachment of handles to heads are various: the position of the centre of gravity of the head in reference to the line of penetration of the handle is various; the faces have various convexities; the panes have all ranges and forms, from the hemispherical end of the engineer's hammer, and the sharpened end of the pick and tomahawk, to the curved

sharpened edge of the adze, or the straight convex edge of the hatchet and axe; the panes make all angles with the plane in which the hammer moves.



FIGS. 13, 14.—BOILER-MAKER'S HAMMERS.

FIG. 15.—COOPER'S CLAW-HAMMER.

FIG. 16.—SHIP-CARPENTER'S CLAW-HAMMER.

Fig. 16 is a ship-carpenter's hammer-head with claw. It differs from ordinary claw-hammers in that the handle is not strapped. In some American claw-hammers the strapping is carried up the back and

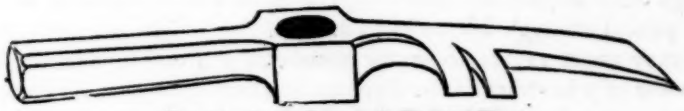


FIG. 17.—COACH-TRIMMER'S HAMMER-HEAD.

front of the hammer. Why this change has been made is not very apparent, for by it one strap—that nearest the claw—is in tension, while the other is in compression. With the straps on the sides, as in Figs. 18, 19, the tension is equal on both. Fig. 15 is a cooper's claw-

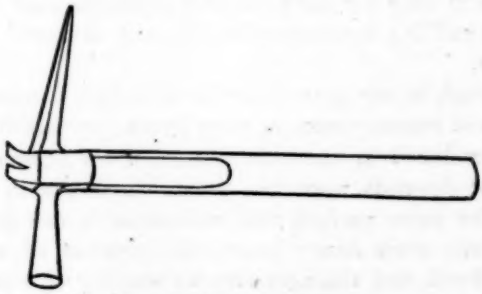


FIG. 18.—SLATER'S HAMMER.

hammer, not strapped. In these cases, if much power is required when the claw is used, it should be applied by pressure on the face-end of the hammer as well as upon the handle.

Before considering the elements upon a combination of which the powers of hand-hammers depend, it will be well to remark upon the circumstances under which this power is actually developed. The development takes place at the instant of contact of the moving hammer with the struck body. Such contacts as those of hammers

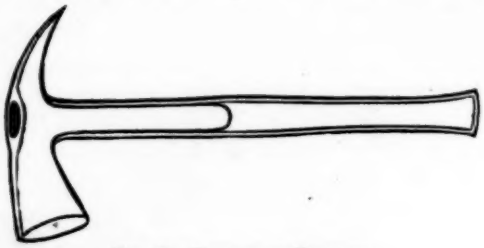


FIG. 19.—TOMAHAWK-HAMMER.

belong to that department of mechanical philosophy called "impact." Impact is pressure of short duration—so short that, compared with the time in which the velocity of the impinging body is being acquired, it is inappreciable; or, if the comparison be between spaces passed through by the hammer-head before impact and during impact, then, generally speaking, the disproportion is the same, and the space passed through after impact is almost inappreciable when compared with the space passed through before impact.

It may assist in realizing the source as well as the magnitude of the power of a hammer, if the dynamical effect of impact be compared with what may be called the statical effect of pressure. Let any one attempt to drive a nail vertically into an horizontal piece of timber by the statical effect of the simple pressure of a load placed gently on the head, as weights are laid in scale-pans. Let the depth to which the nail is thus moved be measured. Again, let the same nail, under the same circumstances, be driven to the same depth by the impact of a hammer-head, then it may for our present purpose be said that the load placed on the nail is a representative statical measure of the impact of the hammer.

Now, although in any given case the work in a hammer consequent on its mass and velocity may be very great, yet utilizing the whole of the work produced in the expenditure of the accumulated power in the hammer depends upon the resistance met with at the instant of impact. The more perfect this resistance is, the greater will be the value of the work done; hence the practice of using massive anvils, firmly fixed, and the necessity for staying all vibrations in the body struck. Let any one attempt to drive a nail in a board not firmly supported, and then by the use of the same means drive a similar nail into the same board supported, and he will appreciate the importance of resistance to the progress of a hammer's motion if the full effect of a blow be desired.

The only exception to this is to be found in the blows given to minerals which are to be cleft, and not crushed. In their case it is desired to give only such a blow as shall accomplish the cleaving; any surplusage of energy, if expended on the material, would, of course, produce fractures over and above the required cleavage. Provision must be made for the dissipation of this superfluous energy, and it is done by placing the mineral in an elastic holding, the nature of the required elasticity being determined by experience, as different substances require different elasticities in the supports by which they are held for cleavage. Illustrations of the principle here enunciated are seen in the breaking of stones on the highway, where the elasticity is transferred from the mineral support to the handle of the hammer; also in the flaking of flints, where the elasticity is obtained by holding the mineral in the hand and supporting it on the knees. The splitting of the diamond is a case where these principles and considerations claim the greatest care.

The anvil used by the diamond-splitter is of wood, in shape not unlike a ninepin, but tapered at the lower end so as to be placed upright in a coned hole in a small block of lead. On the head of the ninepin is a flat, on which, by means of cement, the diamond to be split can be firmly fixed. Placed here so that the plane of intended cleavage shall be vertical when the wooden anvil is in the lead block, a deep scratch is made by a second diamond, in which scratch the edge of the splitter's chisel is to be planted. The diamond-splitter's chisel is very like an old razor. This chisel the workman holds in his left hand, in his right he holds that which is his hammer. The hammer is a plain steel rod, about eight inches in length, and tapering from about half an inch diameter in the middle to three-quarters of an inch at the end. The very construction of this peculiar hammer gives the operator a large range for precise and graduated blows; within certain limits he can most carefully arrange that the path of the centre of percussion, the place of impact, the line bisecting the angle of his razor-like chisel, and the expected plane of cleavage of the diamond, shall coincide; hence, with great coolness and the absence of all hesitation, he gives a blow, upon the effect of which many hundreds of pounds may depend.

In dealing with hammers—including under that term for the present purpose axes, hatchets, adzes, and picks—the following question claims consideration: What power or energy is in a hammer of known weight, moving at a known velocity, if brought to a state of rest by impact on a block? Another question also suggests itself: Can this impact effect of a hammer be converted into simple pressure, and be stated as a load or weight placed, where the impact was requisite, to produce the same effect as the impact did? If the mode of solving the first question can be made clear, then the answer to the second can be easily obtained. The measurable elements which affect the

result are a variation in the mass of the hammer-head, and a variation in the length of the handle. By a varied mass there is a varied weight in the hammer; by a varied length of handle there will, with the same muscular effort, be a varied velocity in this mass, and upon a combination of mass and velocity depends the produced energy. Now, if a mass of metal, moving at a known velocity, strike an object, the energy of that blow results entirely from the conditions at the moment of impact. For example, the work in the hammer, *H*, as it strikes the nail, *N* (Fig. 20), does not depend upon its velocity through the arc,

FIG. 20.

Q N, but only upon the velocity when commencing contact with the nail. Hence, so long as the material which gives the blow and the mass of it are the same, it is not of any consequence how the velocity was accumulated. It may result from centrifugal or rectilinear action; it may result from muscular effort, or from steam-pressure, or from gravity.

It may now be obvious that, other elements remaining unchanged, whatever accelerates the velocity of a hammer increases, according to very clear rules, the energy or power of the same hammer. Hence the tendency of contrivances, as manifested in the addition to steam as well as handicraft hammers; for example, in the early lift-hammers,

those which are by many still considered to produce the most perfect of hammered work, the "wiper" was so shaped as to throw the hammer very high. The ascent was checked by a powerful spring, and thus the ascensional energy was reversed and added to the accelerating force of gravity downward; and so not only was the intensity of the blows increased, but their frequency also. This spring took the place of that muscular energy which brought the hammer down with intensified effect.

Hence, also, in steam-hammers, all muscular effect to intensify the blow is transferred to the steam, and all consequences of centrifugal action, whether from hand or tilt hammers at the ends of arms, are removed. Further, in steam-hammers nowadays, the steam operates to check as well as to intensify the blow. This checking action is called "cushioning," and it seems to do what an elastic handle does in a sledge-hammer: it relieves the rigid fabric or erection from jar or destruction. "Cushioning" is brought into play by admitting steam for the purpose of checking the intensity of the blow due to the action of gravity alone, or of steam combining with gravity upon the hammer. Hence the perfect control over large steam or air worked hammers, and the rapidity with which the intensity of the blow may be changed. Such control as this over a sledge-hammer is beyond our bodily powers. We may intensify the blow, but we cannot, except just experimentally, and for the purpose of display, bring the restraining power of the muscles to diminish the energy of the descending hammer.—*Journal of the Society of Arts.*

PREPOSSESSIONS FOR AND AGAINST THE SUPERNATURAL.

A CRITICISM OF DR. CARPENTER.

By JAMES McCOSH, LL. D.,
PRESIDENT OF PRINCETON COLLEGE.

DR. CARPENTER is master of the domain which he has appropriated for the last age, that of physiology. He has done more than any living man, not exactly to advance, but to combine and expound, the discovered truths of his science. But he is ever impelled by his intellectual sharpness and his cultivated tastes to take excursions into other regions, and I am not sure whether he has there been so successful. In particular, as dwelling so near the territory of mind, he has ever been crossing into it. He has made a very careful survey of the border-country, and given us the result in his valuable work "Mental Physiology." Ever since the palmy days of mesmerism and table-

turning, he has been enlarging on that "expectancy" and "prepossession" which have been so perverting the vision of many in their observation of facts. He will not be offended with me if I hint that it is just possible that he himself may unconsciously be under the influence of these, when, on finding how much can be explained by physiological processes, he imagines he can account in the same way for purely mental operations.

On some points Dr. Carpenter has been vigorously opposing the materialism of the day: "In reducing the thinking man to the level of a puppet, that moves according as its strings are pulled, the materialistic philosopher places himself in complete antagonism to the positive conviction, which, like that of the existence of an external world, is felt by every right-minded man, who does not trouble himself by speculating upon the matter, that *he really does possess a self-determining power*, which can rise above all the promptings of suggestion, and can, *within certain limits*, mould external circumstances to its own requirements instead of being completely subjugated by them."—("Mental Physiology," § 5.) By such utterances, worthy of the son of Lant Carpenter, of Bristol, he has gained the confidence of a number of anti-materialistic and religious men, who may find, however, that he is conducting them into a place between two armies where they are exposed to the fire of both. At this point he has been abandoned by the disciples of Bain, Huxley, and Tyndall, by M. Ribot, and the writers in the *Revue Scientifique*, the organ of the school in France who wonder that he should stop where he has. For, if material agency can generate so much, can account for imagination and genius generally, can explain our higher intellectual efforts of judgment and reasoning, can fashion conscience and gender the obligation of duty and the sense of guilt, and our reverence for the unseen and the sublime, why may it not also produce will, an operation evidently so swayed by causes? They who follow Dr. Carpenter will soon find that they have very insecure footing, and must either go forward and identify will, as they do intelligence, with material agency, or retreat so far back as to hold that there are many other operations, such as the discernment of higher truth and higher goodness, which cannot be derived from atoms. If there be such an agent as will—and I agree with Dr. Carpenter in thinking that consciousness testifies in its behalf—then we must provide a compartment for it, and we may place there reason and our ideas of the good, the infinite, and the perfect.

Dr. Carpenter's views of the attributes of the mind seem to me to be very inadequate. They were formed about the time when Hartley's "Observations on Man" and James Mill's "Analysis of the Human Mind" were reckoned the highest authorities among the Unitarians who felt Priestley's influence. Dr. Carpenter evidently looks upon the operations of the mind as composed of sensations and ideations. His view of both these is very insufficient. In all sense-per-

ception, there is more than mere sensation considered as a feeling; there is knowledge of something extended. Then along with every perception there is consciousness of self as perceiving. According to the school of James Mill, sensation is a mere feeling, and ideation is a reproduced sensation. Memories, imaginations, conceptions, are all ideations; nay, judgments and reasonings are only combined ideations. The sense of duty is the product of association of ideations founded on sensations of pleasure and pain. Dr. Carpenter proceeds, in fact, on this psychology. But, to his credit, he draws back at a certain point. He stands up resolutely for a self-determining will which he places above both sensation and ideation. When asked for his proof, he appeals very legitimately to a "conviction" felt by every mind. But a like conviction certifies that there is vastly more than he sees in operations which he has passed over so lightly; that in memory the idea of time is involved, as every thing is remembered as happening in time past; that in imagination there is a wonderful arranging power; in conception, a grouping power; and in judgment, the discovery of relations such as those of identity, of quantity, and cause and effect, all diving deep into the depth of things, while the conscience gives us an entirely new idea, that of good and evil, and makes us feel that we owe duties to God and our fellow-men. He who overlooks these attributes may imagine that he can identify mental operations with physiological; but it is simply because he has not noticed the characteristic attributes of the human mind.

Dr. Carpenter did essential service to science, to religion, and I may add to common-sense, by exposing the alleged evidence in behalf of mesmerism and table-turning. He showed that, in regard to these phenomena, there were a "prepossession" and an "expectancy" which led persons to believe and affirm, without any valid proof, that they witnessed certain actions. I cannot see, however, that Dr. Carpenter has here unfolded any new truth, or that he has explained the nature of this "expectancy"—certainly no light can be thrown upon it by physiology. It is to be accounted for by purely mental causes, by a hasty judgment into which people are led by the association of ideas, guided by the wishes or feelings of the heart. If we have been accustomed to see two things together, on one of them presenting itself we are apt to look for the other, and believe that this other is present when we have no valid proof. It is thus that, associating the standing on a steep precipice with a fall, many tremble when placed there, even though there be no real danger. It is thus we account for the apparent deception of the senses. We rapidly infer that an object seen across an arm of the sea or a level plain is near, following the rule, usually correct, that an object is near when there are few visible objects between us and it. It is thus that a countryman, seated, and, as he feels, at rest, on a vessel leaving the quay, momentarily reasons that the quay is moving, as he has found that when he is at rest

the object whose image passes over his eye is in motion. It is thus that when a person has come to us habitually at a certain hour, say the postman to deliver our letters, we may readily take some other person who appears at the time for him, and be ready to affirm or to swear that we saw him. It is thus that "the wish is father to the thought;" that is, we are inclined to believe what we wish and expect. It is thus, too, that in times of excitement, personal, political, and religious, we readily fall in with the fancies created by our fears and our hopes. Not only so, but a vivid idea reaching down from the brain may produce the same effect on the sensorium as the external object does through the sense of sight or hearing. Dr. Carpenter has seized an important truth in explaining in this way the erroneous declarations given by honest enough persons believing in mesmerism and spirit-rapping, and ever seeking for signs and wonders. He is right, too, in explaining how strong religious feelings may raise illusory expectations and beliefs, and that the testimony given by persons under their influence may be partial or valueless.

I think I discover proof that even scientific men may fall under the influence of this "prepossession" and "expectancy." I see an example of it in the way in which many of them account for our thoughts and resolutions: they call them reflex action. The discovery of the nature of automatic motion was one of the most important discoveries of the last age. An action goes along a nerve to the centre of a ganglion, and comes out in motion by another nerve: thus, if a frog's foot is pricked, it is immediately drawn in. Of much the same kind is the reflex action of the sensori-motor system. My nostrils are affected by a pungent substance, the action goes on to the sensorium, and a sneeze is the result. So far we have a well-understood process. But can we go on to explain in this way our special mental acts? The language used by some physiologists is fitted to leave the impression that all mental action is the reflex of some action from without, probably a sensation. Let us look at a case. I receive a letter informing me that a friend at a distance is in deep distress, needs me to defend him by my presence, my purse, and my counsel, against a false accusation, and I hasten to his assistance. Is all this merely a reflex action called forth by the appeal in the letter? Let us carefully inquire how much and how little physiology can explain. It can show how the writing in the letter, after passing through the eye, is reflected on the retina, thence carried through the optic nerve to the sensorium, thence it may be transmitted to the gray matter at the periphery of the brain, and produce there, it may be, some motion or new arrangement of the cells. But it can go no farther. When I understand the letter, when I comprehend the position of my friend, when I conclude that the accusation against him is false, when I feel that I ought to assist him, and for this purpose travel a long way and make many sacrifices, we have come to processes that cannot be explained

by any external impulse; which can as little be accounted for by reflex action as they could by gravity or by chemical affinity. Then there are cases in which the action originates within, with no prompting from without. I awake in the morning and I think and conclude that some good cause, the cause of liberty, or of my country, or of religion, requires me to take a bold, decisive action, and I hasten to put my purpose in execution. How absurd to call this, with some physiologists, a reflex action! That able men should have fallen into this error can only be accounted for by a law of "expectancy;" they have explained so much by their law, and they think that they can explain everything.

Dr. Carpenter has unfolded, as Hume had done a century ago, the tendencies which predispose man to believe in preternatural occurrences. But are there no "prepossessions" and "expectations" which incline some scientific men in the present day to account for all things by natural agency, and prejudice them against calling in any thing preternatural? The business of science is to look into the causes of obvious or recondite phenomena, and, proceeding in the right method, they have discovered the natural causes of events which many regarded as supernatural. The men who have explained lightning and mysterious diseases, and resolved light into vibrations, and detected the composition of the sun's atmosphere, and of the distant stars, are led to spurn at the very idea of there being any thing which cannot be accounted for by mundane agency. Then they have seen, or heard, or read, of so many cases of religious pretension and imposture that they at once set down every reported case of divine interposition to illusion or delusion. Some have gone the length of maintaining that a miracle is not only an improbability, but an impossibility. A "prepossession" is produced, an "expectancy" is created, that the miracles of Scripture may be solved by some natural means. In the last age Paulus labored to prove that Jesus accomplished his cures by taking advantage of the secret agencies of Nature. But this theory has long ago been set aside by every one as inconsistent with the training, the position, and known character of Jesus. Then the mythic theory was started and stretched to its utmost capacity by Strauss; but it has been shown that no myths ever had the consistency, the purity, the spirituality of the gospel narratives, parables, and doctrines. Now it is averred that historical proof is wanting of the early date of the books of the New Testament. This objection has been met already by the great scholars of Germany, and is being met by Dr. Lightfoot and others among English-speaking divines. It is shown and is admitted that some of the epistles of Paul must have been written by their reputed author, and that they presuppose a belief throughout the Church of the leading events in Christ's life, and of a perfected system of evangelical belief. If the epistles are genuine, so must be the correlated Book of Acts, with its wonderful

story of the spread of the gospel, the only "working hypothesis" to explain the facts. The synoptics bear internal marks of being genuine; give a consistent tale to account for the state of things as detailed by Paul and the Book of Acts; and have external testimony accumulating in their favor derived especially from the controversies with the early heretics. Even John's gospel is brought within a hundred years of our Lord's death, almost certainly in the first century, is shown to be as little inconsistent with the synoptics as Plato's Socrates is with Xenophon's Socrates, and breathes an air so superior to that of the Apostolic Fathers, that we see the one to be heaven-descended, the other to be the product of imperfect human nature at a time when the minds of Christians were saturated with divine truth. It is clear that the "expectancy" of accounting for the life of Christ by human causes has not yet been realized. "The Bible," as Beza said, "is an anvil which has worn out many hammers."

Every one knows that all men, scientific and unscientific, are liable to be swayed by prejudice, and Dr. Carpenter has not been able to throw much light on this subject by physiology. Even mathematicians may have their "personal equation." Philosophers, so called, and scientists have fallen under the influence of the idols of Bacon, and not a few other idols which have been set up since his time. Historical investigators, judges, and juries, are all aware of its existence, and should guard against it. We meet with it in our daily intercourse with our fellow-men, and make allowance for it. We see it in the village parties, in political contests, and in the rivalries of rank and trade. To every reality there is a counterfeit; corresponding to every truth there is a false appearance; if there be one Jehovah, there are many idols. Many, when they look to the dust of the conflict, are tempted to conclude that Truth cannot be found. But, notwithstanding all this, Truth can be found and won by those who court her in the right manner and the right spirit. It is to be remembered, however, that while we are required to demand evidence before yielding our conviction, all evidence is not of the same kind. "I receive mathematics," said Goethe, "as the most sublime and useful science as long as they are applied in their proper place; but I cannot commend the misuse of them in matters which do not belong to their sphere, and in which, noble science as they are, they seem to be mere nonsense, as if, forsooth, things only exist when they can be mathematically demonstrated! It would be foolish for a man not to believe in his mistress's love because she could not prove it to him mathematically. She can mathematically prove her dowry, but not her love." Some scientists in our day are insisting that every thing, even in history, morals, and religion, is to be settled by experiment and calculation, and would place all truth under the microscope—subject it to the blowpipe, and express it in statistics—and they do not see that the highest truth escapes in the process. The defenders of religion

maintain that in religion a sincere mind will discover the truth with or without scientific knowledge. Many believe that John Bunyan saw as far into spiritual matters as even Newton or Locke, and much farther than Laplace ever did. Some of the highest statesmen and lawyers in Great Britain imagined that they could get more good from the direct and homely appeals of Moody than from those select *dilettant* meetings in London of *savants* and *littérateurs* who have abandoned Christianity, and are seeking to catch some higher religion which evanishes as they would lay hold of it.

Everybody acknowledges that all witnesses are not to be trusted; yet in the common affairs of life, in trials, in history, we do find testimony which we implicitly believe. To the great body even of educated men, scientific knowledge depends on the trustworthiness of those who have made the observations and experiments. Notwithstanding all their preconceptions, there are declarations of men of science as to matters of fact which we can trust; and it would be a violation of their whole nature, in fact it would be a miracle, were they to deceive us. Dr. Carpenter is entitled to credit for having helped to expose the fooleries and the rogueries of spirit-rapping, rope-tying, and of levitation. But he seems to think that it is possible by the same method to undermine the miracles of the Old and New Testaments. All who have inquired carefully into the subject see that the testimony in favor of spiritualistic manifestations cannot stand the common tests of evidence. But it has been maintained by many of the greatest and most sagacious minds, and by the highest moral minds which our world has produced, that the testimony in behalf of the essential events of the New Testament cannot be set aside without undermining the whole of ancient history. Even at first sight the spiritual *séances* and performers have no moral prestige in their favor. The products are unworthy of God, and inconsistent with his mode of operation in Nature. We can discover motives enough to induce them to act as they do—such as the desire to create wonder—with some the hope of getting money. How different with our Lord, who, so far from taking advantage of the wonder-loving spirit of the Jews, actually restrained it! The wonders of the spiritualists are performed in rooms prepared for the purpose or in darkness, whereas the miracles of our Lord were performed in open day, in unexpected circumstances, and before all men. Then the whole teaching of Jesus was totally above and altogether opposed to the spirit of his age and nation, and only exposed him and his followers to opprobrium, poverty, and suffering.

But Dr. Carpenter has discovered that there is no stronger evidence in behalf of the events of our Lord's life than we have in favor of the miracles attributed to St. Columba. This is a proof that, amid his multifarious employments, Dr. Carpenter has not carefully surveyed or minutely examined the whole body of Christian evidences. The

only original life of Columba is the "Vita" of Abbot Adamnan, written about one hundred years after the saint's death. All that it proves is, that at the time the life was written Columba was believed to have wrought miracles. But there is satisfactory proof that the first gospels were written while many who had seen the events were still alive. The account given by the abbot was all in accordance with the popular belief, and had not, like the earlier Christian records, to encounter the hostile criticism of keen and able opponents. The voice of the Irish dove was a very pleasant one, but all the good words uttered were got from him on whom the spirit alighted as a dove. We have no utterances of his to be compared with the teachings of our Lord and his disciples. Then we have no record of such lives and sacrifices as are described in the letter of Pliny the Younger in A. D. 112. Nor have we such corroborations as the Book of Acts, such original productions as the Epistles of Paul, such a mighty result as Christianity with its influence over the world, over its education and its civilization, for the last eighteen hundred years.

Dr. Carpenter quotes Locke as saying that we are to regard the doctrine as proving the miracle rather than the miracle proving the doctrine. Locke believed both the doctrine and the miracle. Dr. Carpenter does not tell us whether he believes either. He does not say whether he looks on the doctrine as proving the miracle. The wisest defenders of Christianity have always combined the two, the lofty teaching and the high morality, with the attested supernatural action. In estimating the validity of even common testimony we combine the character of the witness with the facts to which he depones. We look to his manner of testifying, to the consistency and transparency of his statements, even to the name he has borne among his associates and the motives by which he may have been swayed. So in weighing the evidence we have for Christianity we are entitled to combine the truth testified to with the testimony. We do not choose to separate the record of miracles in Matthew from the Sermon on the Mount. We are prepared to believe that he who uttered those bold and transparently sincere and pure precepts could not have been guilty of deceit. It is clear that Jesus claimed supernatural power. If there be any truth at all in the accounts of him, in fact, if there ever was such a person as Jesus, it is clear that he claimed to work miracles. His claims are found imbedded in the heart of discourses which contain his loftiest ideas, moral and spiritual, far beyond the conception of the evangelists or the early Christian writers. His discourses are, in fact, his greatest miracle. His acts and words are like the warp and woof of his garment, which is woven throughout and cannot be divided.

The doctrines, the precepts, the providential occurrences, the miracles, constitute a system quite as much as the Cosmos does. In this system one part supports another, each helps to bear up the whole, and

the whole makes every part cohere. He who assails Christianity has to attack a phalanx. The pure morality fits in to the character of God, revealed as a spirit, revealed as light, revealed as love. The miracles, being almost all of them meant to remove evil, most of them to heal diseases, adapt themselves to the manifest disorder in the world, to our consciousness of sin, and the doctrine which reveals an atonement. The supernatural system is higher than the natural, but it is in accordance with it. The higher joins on beautifully to the lower quite as fittingly as vegetable life superinduces itself on inanimate Nature, as animal life completes vegetable life, as the soul fits into the body. Science and philosophy may not be able to go back to a beginning, but they require a source. It is not more certain that "*ex nihilo nihil fit*" than it is that what produces must have power to produce. All these later discussions as to force and cause show that there must be some intimate connection between the effect and its cause. Mayer wrought out the grand doctrine of the conservation of force by the principle that "cause equals effect." This is not, as it appears to me, the correct expression of the law, but it points to a deep law lying at the basis of that development which men are studying so eagerly in the present day. All that is in the effect has come from the causes—it may be the successive causes. We are thus carried back to an inherent power, not created by development, but the source or spring of development. This source may surely be declared supernatural. The Bible simply speaks of the continuance of that supernatural in revelation and in inspiration. This supernatural is not inconsistent with the natural; it is the complement of it. The higher world overarches the lower world as the sky does the earth. The world to come consummates what is begun in the present world—provides a place for the immortal soul, and for the body raised to join it.

The conclusion of the whole matter is, that we are to weigh the evidence in behalf of revelation in the same way as we weigh any other evidence, laying aside all "prepossessions" and "expectancies" for and against supernaturalism; and that the evidence for Christianity, so large, so varied, so compact, is not to be summarily set aside by any physiological doctrine sufficient to explain mesmerism and spirit-rapping.

LESSONS IN ELECTRICITY.[1]

HOLIDAY LECTURES AT THE ROYAL INSTITUTION.

By Prof. TYNDALL, F. R. S.

II.

SECTION 8. *Electrics and Non-Electrics.*—For a long period, bodies were divided into *electrics* and *non-electrics*, the former deemed capable of being electrified, the latter not. Thus the amber of the ancients, and the spars, gems, fossils, stones, glasses, and resins, operated on by Dr. Gilbert, were electrics, while all the metals were non-electrics. We must now determine the true meaning of this distinction.

Take in succession a ball of brass, of wood coated with tin-foil, a lead bullet, and an apple, in the hand, and strike them briskly with silk, flannel, or the fox's brush; none of them will attract the balanced lath (Fig. 4), or show any other symptom of electric excitement. All of them, therefore, would have been once called non-electrics.

But suspend them in succession by a string of silk held in the hand, and strike them again; every one of them will now attract the lath.

Reflect upon the meaning of this experiment. We have introduced an insulator—the silk string—between the hand and the body struck, and we find that by its introduction the non-electric has been converted into an electric.

The meaning is obvious. When held in the hand, though electricity was developed in each case by the friction, it passed immediately through the hand and body to the earth. This transfer being prevented by the silk, the electricity, once excited, is retained, and the attraction of the lath is the consequence.

In like manner, a brass tube, held in the hand and struck with a fox's brush, shows no attractive power; but when a stick of sealing-wax, ebonite, or gutta-percha, is thrust into the tube as a handle, the striking of the tube at once develops the power of attraction.

And now you see, more clearly than you did at first, the meaning of the experiment with the heated foolscap and India-rubber. Paper and wood always imbibe a certain amount of moisture from the air. When the rubber was passed over the cold paper, electricity was excited, but the paper, being rendered a conductor by its moisture, allowed the electricity to pass away.

Prove all things. Lay your cold foolscap on a cold board, supported by warm dry tumblers; pass your India-rubber over the paper; lift it by a loop of silk, for if you touch it it will discharge itself.

[1] A course of six lectures, with simple experiments in frictional electricity, before juvenile audiences during the Christmas holidays.

You will find it electric; and with it you can charge your electroscope, or attract from a distance your balanced lath.

The human body was ranked among the non-electrics. Make plain to yourself the reason. Stand upon the floor and permit a friend to strike you briskly with the fox's brush. Present your knuckle to the balanced lath, you will find no attraction. Here, however, you stand upon the earth, so that even if electricity had been developed, there is nothing to hinder it from passing away.

But, place upon the ground four warm glass tumblers, and upon the tumblers a board. Stand upon the board, and present your knuckle to the lath. A single stroke of the fox's fur, if skillfully given, will produce attraction. If you stand upon a cake of resin, of ebonite, or upon a sheet of good India-rubber, the effect will be the same.

Throw a mackintosh over your shoulders, and let a friend strike it with the fox's brush, the attractive force is greatly augmented.

After brisk striking, present your knuckle to the knuckle of your friend. A spark will pass between you.

This experiment with the mackintosh further illustrates what you have already frequently observed, namely, that it is not friction alone, but the friction of special substances against each other, that produces electricity.

Thus we prove that non-electrics, like electrics, can be excited, the condition of success being, that an insulator shall be interposed between the non-electric and the earth. It is obvious that the old division into electrics and non-electrics really meant a division into insulators and conductors.

SEC. 9. *Discovery of Two Electricities.*—We have hitherto dealt almost exclusively with electric attractions, but, in an experiment already referred to, Otto von Guericke observed the *repulsion* of a feather by his sulphur globe. I also anticipated matters in the use of our Dutch gold electroscope, where the repulsion of the leaves informed us of the arrival of the electricity.

Du Fay, who was the real discoverer here, found a gold-leaf floating in the air to be at first attracted and then repelled by the same excited body. He proved that when it was repelled by rubbed glass, it was attracted by rubbed resin—and that when it was repelled by rubbed resin, it was attracted by rubbed glass. Hence the important announcement, by Du Fay, that there are two kinds of electricity.

The electricity excited on the glass was for a time called *vitreous* electricity—while that excited on the sealing-wax was called *resinous* electricity. These terms are, however, improper; because, by changing the rubber, we can obtain the electricity of sealing-wax upon glass, and the electricity of glass upon sealing-wax.

Roughen, for example, the surface of your glass tube, and rub it with flannel, the electricity of sealing-wax will be found upon the vit-

reous surface. Rub your sealing-wax with vulcanized India-rubber, the electricity of glass will be found upon the resinous surface.

We now use the term *positive* electricity to denote that developed on glass by the friction of silk; and *negative* electricity to denote that developed on sealing-wax by the friction of flannel. These terms are adopted purely for the sake of convenience. There is no reason in Nature why the resinous electricity should not be called positive, and the vitreous electricity negative. Once agreed, however, to apply the terms as here fixed, we must adhere to this agreement throughout.

SEC. 10. *Fundamental Law of Electric Action.*—In all the experiments which we have hitherto made, one of the substances has been electrified by friction, and the other not. But, once engaged in inquiries of this description, questions incessantly occur to the mind, the answering of which extends our knowledge, and suggests other questions. Suppose, instead of exciting only one of the bodies presented to each other, we were to excite both of them, what would occur? This is the question which was asked and answered by Du Fay, and which we must answer for ourselves.

Here your wire loop (Fig. 1), comes again into play. Place an unrubbed gutta-percha tube, or a stick of sealing-wax, in the loop, and be sure that it *is* unrubbed—that no electricity adheres to it from former experiments. If it fail to attract light bodies, it is unexcited; if it attract them, pass your hand over it several times, or, better still, pass it over or through the flame of a spirit-lamp or candle. This will remove every trace of electricity. Attract the unrubbed gutta-percha tube by a rubbed one.

Remove the unrubbed tube from the loop, and excite it with its flannel rubber. One end of the tube is held in your hand, and is therefore unexcited. Return the tube to the loop, keeping your eye upon the excited end. Bring a second rubbed tube near the excited end of the suspended one: strong repulsion is the consequence. Drive the suspended tube round and round by this force of repulsion.

Bring a rubbed glass tube near the excited end of the gutta-percha tube: strong attraction is the result.

Repeat this experiment step by step with two glass tubes. Prove that the rubbed glass tube attracts the unrubbed one. Remove the unrubbed tube from the loop, excite it by its rubber, return it to the loop, and establish the repulsion of glass by glass. Bring rubbed gutta-percha or sealing-wax near the rubbed glass: strong attraction is the consequence.

These experiments lead us directly to the fundamental law of electric action, which is this: Bodies charged with the same electricity repel each other, while bodies charged with opposite electricities attract each other. Positive repels positive, and attracts negative. Negative repels negative, and attracts positive.

Devise experiments which shall still further illustrate this funda-

mental law. Repeat, for example, Otto von Guericke's experiment. Hang a feather by a silk thread, and bring your rubbed glass tube near it: the feather is attracted, touches the rod, charges itself with the electricity of the rod, and is then repelled. Cause it to retreat from the rod in various directions.

Hang your feather by a common thread: if no insulating substance intervenes between the feather and the earth, you can get no repulsion. Why? you ought to be able to answer. Obviously it is because the charge of positive electricity communicated by the rod is not retained by the feather, but passes away to the earth. Hence, you have not positive acting against positive at all. Why you should have the attraction of the neutral body by the electrified one will, as already stated, appear by-and-by.

Attract your straw needle by your rubbed glass rod. Let the straw strike the rod, so that the one shall rub against the other. The straw accepts the electricity of the rod, and repulsion immediately follows attraction, as shown in Fig. 7.

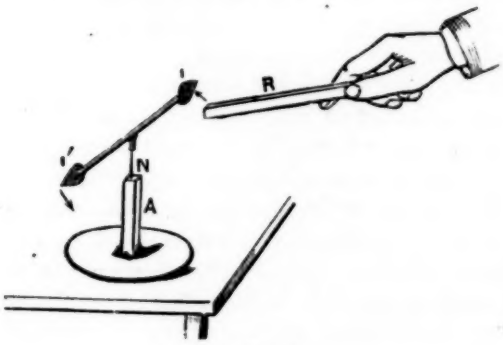


FIG. 7.

Mr. Cottrell has devised the simple electroscope represented in Fig. 8 to show repulsion. *A* is a stem of sealing-wax, with a small circle of tin, *T*, at the top. *W* is a bent wire proceeding from *T*, with a small disk attached to it by wax. *I I'* is a little straw index, supported by the needle, *N*, as shown in the figure. The stem, *A*, is not quite vertical, the object being to cause the bit of paper, *I*, to rest close to *W* when the apparatus is not electrified. When electricity is imparted to *T*, it flows through the wires, *W* and *w*, over both disk and index: immediate repulsion of the straw is the consequence.

No better experiment can be made to illustrate the self-repulsive character of electricity than the following one: Heat your square board again, and warm, as before, your sheet of foolscap. Spread the paper upon the board, and excite it by the friction of India-rubber. Cut from the sheet two long strips with your penknife. Hold the strips together at one end. Separate them from the board, and

lift them into the air: they forcibly drive each other apart, producing a wide divergence.

Cut several strips, so as to form a kind of tassel. Hold them together at one end. Separate them from the board, and lift them into the air: they are driven asunder by the self-repellent electricity, pre-

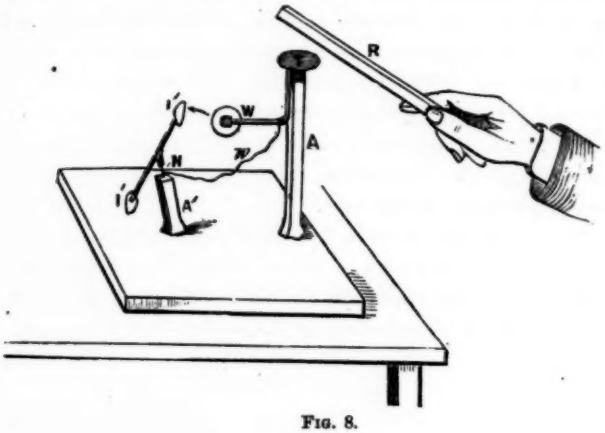


FIG. 8.

senting an appearance which may remind you of the hair of Medusa. The effect is represented in Fig. 9.

And now you must learn to determine with certainty the quality of the electricity with which any body presented to you may be charged. You see immediately that attraction is no sure test, because unelectrified bodies are attracted. Further on you will be able to grapple with another possible source of error in the employment of attraction.

FIG. 9.

In determining quality, you must ascertain, by trial, the kind of electricity by which the charged body is repelled; if, for example, any electrified body repel, or is repelled by, sealing-wax rubbed with

flannel, the electricity of the body is negative; if it repel, or is repelled by, glass, rubbed with silk, its electricity is positive. Du Fay had the sagacity to propose this mode of testing quality.

Apply this test to the strips of foolscap paper excited by the India-rubber. Bring a rubbed gutta-percha tube near the electrified strips, you have strong attraction. Bring a rubbed glass tube between the strips, you have strong repulsion and augmented divergence. Hence, the electricity, being repelled by the positive glass, is itself positive.

SEC. 11. *Double or "Polar" Character of the Electric Force.*—We have examined the action of each kind of electricity upon itself, and upon the other kind; but hitherto we have kept the rubber out of view. One of the questions which inevitably occur to the inquiring scientific mind would be, How is the rubber affected by the act of friction? Here, as elsewhere, you must examine the subject for yourself, and base your conclusions on the facts you establish.

Test your rubber, then, by your balanced lath. The lath is attracted by the flannel, which has rubbed against gutta-percha; and it is attracted by the silk, which has rubbed against glass.

Regarding the quality of the electricity of the flannel or of the silk, the attraction of the lath teaches you nothing. But, suspend your rubbed glass tube, and bring the flannel rubber near it: repulsion follows. The silk rubber, on the contrary, attracts the glass tube. Suspend your rubbed gutta-percha tube, and bring the silk rubber near it: repulsion follows. The flannel, on the contrary, attracts the tube.

The conclusion is obvious: the electricity of the flannel is positive, that of the silk is negative.

But the flannel is the rubber of the gutta-percha, whose electricity is negative; and the silk is the rubber of the glass, whose electricity is positive. Consequently, we have not only proved the rubber to be electrified by the friction, but also proved the electricity of the rubber to be opposite in quality to that of the body rubbed.

SEC. 12. *What is Electricity?*—Thus far we have proceeded from fact to fact, acquiring knowledge of a very valuable kind. But facts alone cannot satisfy us. We seek a knowledge of the *principles* which lie behind the facts, and which are to be discerned by the mind alone. Thus, having spoken, as we have done, of electricity passing hither and thither, and of its being prevented from passing, hardly any thoughtful boy or girl can avoid asking, What is it that thus passes?—what *is* electricity? Boyle and Newton betrayed their need of an answer to this question when the one imagined his unctuous threads issuing from and returning to the electrified body, and when the other imagined that an elastic fluid existed which penetrated his rubbed glass.

When I say "imagined" I do not intend to represent the notions

of these great men as vain fancies. Without imagination we can do nothing here. By imagination I mean the power of picturing mentally things which have an existence as real as that of the world around us, but which cannot be touched directly by the gross bodily organs of sense. I mean the purified scientific imagination, without the exercise of which we cannot take a single step into the region of causes and principles.

It was by the exercise of the scientific imagination that Franklin devised the theory of a single electric fluid to explain electrical phenomena. This fluid he supposed to be self-repulsive, and diffused in definite quantities through all bodies. He supposed that when a body has more than its proper share it is positively, when less than its proper share it is negatively, electrified. It was by the exercise of the same faculty that Symmer devised the theory of two electric fluids, each self-repulsive, but both mutually attractive.

At first sight Franklin's theory seems by far the simpler of the two. But its simplicity is only apparent. For, though Franklin assumed only one fluid, he was obliged to assume three distinct actions. Two of these were the mutual repulsion of the electric particles among themselves, and the mutual attraction of the electric particles and the ponderable particles of the body through which the electricity is diffused. These two assumptions, moreover, when strictly followed out, lead to the unavoidable conclusion that the material particles must also mutually repel each other. Thus the theory is by no means so simple as it appears.

The theory of Symmer, though at first sight the most complicated, is in reality by far the simpler of the two. According to it electrical actions are produced by two fluids, each self-repulsive, but both mutually attractive. These fluids cling to the atoms of matter, and carry the matter to which they cling along with them. Every body, in its natural condition, possesses both fluids in equal quantities. As long as the fluids are mixed together they neutralize each other, the body in which they are thus mixed being in its natural or unelectrical condition.

By friction (and by various other means) these two fluids may be torn asunder, the one clinging by preference to the rubber, the other to the body rubbed.

According to this theory there must always be attraction between the rubber and the body rubbed, because, as we have proved, they are oppositely electrified. This is in fact the case. And mark what I now say. Over and above the common friction, this electrical attraction has to be overcome whenever we rub glass with silk, or sealing-wax with flannel.

You are too young to fully grasp this subject yet; and indeed it would lead us too far away to enter fully into it. But I will throw out for future reflection the remark that the overcoming of the ordi-

nary friction produces heat then and there upon the surfaces rubbed, while the force expended in overcoming the electric attraction may be converted into a spark which shall appear a thousand miles away from the place where it was generated.

Theoretic conceptions are incessantly checked and corrected by the advance of knowledge, and this theory of electric fluids is doubted by many eminent scientific men. It will, at all events, have to be translated into a form which shall connect it with heat and light, before it can be accepted as complete. Nevertheless, keeping ourselves unpledged to the theory, we shall find it of exceeding service both in unraveling and in connecting together electrical phenomena.

RECENT GEOGRAPHICAL PROGRESS.[1]

By Chief-Justice DALY,
PRESIDENT OF THE GEOGRAPHICAL SOCIETY.

THE year 1875 completed the third quarter of the nineteenth century, a period distinguished by the activity which has prevailed in every branch of scientific inquiry, but particularly distinguished as a remarkable period of geographical exploration and discovery.

The history of geographical knowledge is a history of its rapid acquisition in periods very limited in point of time, but of great activity, and of long intervals of repose, in which comparatively little was done, or a great deal lost that had been previously acquired. For the last twenty-five years we have been living in one of those periods of exceptional activity, for at no time has an interest so wide-spread been manifested for geographical exploration since that great age of maritime discovery, that began in the early part of the fifteenth century with the exploration of the western coast of Africa by the Portuguese, and culminated in the circumnavigation of the globe by Magellan. The comparatively small limits of about a century is all that is embraced from the time (1418), when Prince Henry of Portugal, surnamed the Navigator, took up his abode upon the promontory of Sagres to devote the residue of his life to the fitting out of expeditions for the exploration of the coast of Africa beyond Cape Bojador, a region then wholly unknown, and the year 1519, when Magellan entered the Pacific by the discovery of the straits that bear his name. Within that period the captains of Prince Henry had sailed around the continent of Africa; Columbus had discovered America; his companion, Nuñez de Balboa, the Pacific; Sebastian Cabot had followed

[1] From advance-sheets (introductory portion) of the President's annual address before the American Geographical Society, on "The Geographical Work of the World in 1875."

the coast of North America to the sixty-seventh parallel of north latitude; and Magellan's vessel the Vittoria, after sailing around the world, had returned in 1522 to San Lucar, in Spain, the port whence she set out.

The century that followed this period of discovery was occupied with the more particular exploration and settlement of the regions thus brought to the knowledge of mankind, and with the labors of geographers and cartographers in arranging the great mass of new materials into a reconstructed system of geography. With the exception of fruitless efforts to discover, in the interest of commerce, a northeast or a northwest passage to the Indies around the northern part of the globe, or directly across the pole, the zeal for geographical discovery abated through the seventeenth and eighteenth centuries; the world being sufficiently occupied with what it had already acquired, either in building up great empires in the newly-discovered continents of North and South America, or by extending the rule of maritime nations over the coast of Africa, and the remoter parts of Asia, as in the settlement of the colonies established by the Portuguese, and by the British conquest of India. In fact, so large a portion of the earth's surface had become known within so short a period, that it presented enough to absorb all the activity of civilized nations for three centuries in the work of colonization, settlement, or conquest.

It was not until near the middle of the nineteenth century when this great work had produced its results in the establishment of such nations as the United States, Mexico, the republics of Central America, Brazil, the other states of South America, and of a vast dominion under British rule in India, and by the extension of Russia over a large part of Northern Asia, that the attention of mankind was again drawn to the yet undiscovered or imperfectly known portions of the earth, and a new interest awakened in geographical exploration and discovery. This may be said to have begun with the founding of a Geographical Society in Paris, in 1821; of another in Berlin, in 1828, and the establishment of the Royal Geographical Society of London, in 1830. These societies were formed to cultivate the science of geography in a more comprehensive spirit, to facilitate the acquisition of geographical information by the establishment of libraries, to disseminate it by publications, and to encourage and assist scientific travelers and explorers. Like all new things, however, it was some years before these societies produced any effect, or the world recognized the value of the purpose for which they were established; whereas the results which have since been brought about, chiefly through the instrumentality of such institutions, are beyond anything which the most sanguine of their projectors could have anticipated.

The Royal Geographical Society of London may be taken as an illustration of these societies. It has now 3,035 fellows, each paying

£2 a year, a large permanent capital, and an annual income of $35,000. It has a building of its own, a fine library and map room, and is able to send, and has frequently sent out expeditions for geographical exploration and discovery, sometimes in coöperation with the government, and sometimes without it. Before, however, it reached this state it had, as I have been informed, to struggle for some years, as we have had, to keep up its organization. The turning-point of its history, and in its influence, appears to have been the election, in 1843, of Sir Roderick I. Murchison to the presidency, then in the fullness of his fame as a geologist, but who thenceforth entered upon a new field, and one by which he was afterward chiefly known. In his first annual address, an elaborate and exhaustive production, he surveyed the then state of geographical research throughout the world, and pointed out with remarkable sagacity that the parts of the globe to which exploration and research should be directed and concentrated were central Africa, Australia, and the regions surrounding the north and south poles. Although his own fame had been made as a geologist, his course then and during the many years that he was the guiding spirit of the Royal Geographical Society showed very plainly his conviction that a thorough knowledge of the surface of our own planet, and of those physical laws that affect everything upon it, is practically of more importance to us than a knowledge of its past physical history or of other bodies in space.

It was not that he undervalued the sciences of geology and astronomy, which, in fact, form a part of the science of geography; but the earth is our own planet, the details of which are within our grasp, and there is therefore the greater reason why every effort should be directed to acquire a thorough knowledge of it, particularly as the increase of that knowledge requires widely-extended efforts over different parts of it, and a vast accumulation of details. I am not now expressing anything he may have said, but rather deducing my own conclusions of what he thought from what he did. He was evidently impressed with the conviction that sufficient attention was not then given to the advancement of the science of geography, and to his eminently practical mind it was clear that it was not to be advanced by simply studying it in the closet, but by explorations and scientific researches, requiring persistent efforts, continuous expenditures, and the labors of a numerous, zealous, and intelligent class of workers over a large part of the earth's surface. To accomplish this, the whole age had to be influenced, governments enlisted, and the different societies brought into active coöperation with each other, and it was to this work that Sir Roderick then set himself, and to which he may be said to have chiefly devoted the remainder of his life.

I have selected Sir Roderick Murchison rather as a type, for it was not to him alone, but to many other eminent men in France, Germany, Russia, Italy, and other countries, preëminent among whom

was Alexander von Humboldt, that the conviction became general that the unknown, or imperfectly known, parts of the earth should be thoroughly investigated, and scientific researches actively prosecuted in respect to all phenomena coming under the general head of physical geography. This has, in fact, brought about, as I have said, a geographical age. There are now scattered over the globe thirty-four geographical societies, and, if we add other organizations devoted in part to geographical inquiry or labors, the number would be augmented to about fifty. Many of them are well endowed, large in point of numbers, and strengthened not only by the coöperation of, but by annual grants of money from, the governments of the countries in which they are situated.

How thoroughly this spirit was aroused, will appear by a brief, but necessarily imperfect, statement of what has been accomplished since this movement began.

When it commenced, the map of Africa was, with the exception of the northwestern projection, above the Gulf of Guinea, and the Nile region, almost a blank from the Mediterranean to the country in the vicinity of the Cape of Good Hope. Of the 17,000,000 of square miles in Asia, about 12,000,000 were either entirely unknown, or wholly cut off from all intercourse with mankind. The condition of Australia, with an area of 3,000,000 of square miles, is best expressed by quoting the language of a geographer of that day. "A corner of this huge mass of land," he says, "is all that is known." Twenty-five years ago the European population of Australia was estimated at about 50,000; it is now over 1,500,000, or thirty times as great.

The second island in point of size, and one of the most fruitful in the world, Papua, or New Guinea, is referred to by the same geographer Murray, as almost a *terra incognita*, having generally, he then said, "been viewed only by navigators from a distance;" and in respect to the next great island, Borneo, he puts the population of the colonies there under the Dutch at about 9,000. In 1870 the population of the Dutch colonies in Borneo was 189,253. The settled portion of the United States then embraced 800,000 square miles, beyond which was an area of 2,500,000 square miles inhabited by savages, and almost unknown; for we knew little of it then beyond what was known in the time of Jefferson, with the exception of Major Long's journey and Prof. Nicollet's exploration of the head-waters of the Mississippi.

This was the state of things at the beginning of the period referred to. I will now enumerate what has been done since, and especially within the last twenty-five years.

In *Asia:* the opening of the whole of China and Japan; the acquisition by the Russians of nearly the whole of Toorkistan, and the inauguration of a policy on their part which, either by treaty or military conquest, will throw open the whole of Northern Asia to the free

intercourse of the world. The extensive explorations by them in Northern Siberia, and of the rivers that flow into the Arctic. The many journeys, explorations, geographical and archæological, made through Southern Arabia, Persia, Afghanistan, Beloochistan, and the northern regions of India, and explorations of the like character in Burmah, Siam, and Cambodia. The settlement of the French in Cochin-China, and journeys to a partial extent in Corea, and to a greater extent in Mantchooria. The Euphrates Expedition. The continuation of the great survey of India. The survey of Palestine, and the cutting of the Suez Canal.

In *Africa:* the discovery of the great lakes, as well those which are the reservoirs of the Nile, as those lying south of the equator. The exploration of the country south of Abyssinia, between these lakes and the eastern coast, and the discovery of the great range of mountains in that region, with their snow-capped peaks, the most elevated land in Africa. The military occupation of Abyssinia and of Ashantee by the English; the extensive journeys and researches in Northern and Northeastern Africa, by Barth, Overweg, Richardson, Rohlfs, Schweinfurth, Miani, Nachtigal, and others. The various expeditions and individual journeys along the western coast, and the explorations of its immediate interior by Du Chaillu, Burton, Baines, Blyden, Gandy, Güssfeldt, etc., etc. The two journeys across Central Africa, from east to west, and west to east, by Dr. Livingstone; his journey from the Cape upward; his exploration of the Zambezi, and of the countries by which it is watered; his discovery of the great network of rivers and lakes in Central Africa, below the equator, which he was pursuing at the time of his death, and the following up of that exploration by Lieutenant Cameron, with the latter's journey through Central Africa, from east to west. The numerous explorations in South and Southeastern Africa, from the Orange River to the Limpopo, and from that point along the eastern coast and its interior, as far as the parallel of Zanzibar, which, with the exploration of the imperfectly known parts of the Island of Madagascar by Grandidier and Mullins, is but a very general statement of what has been done in Africa. What exploration has accomplished in Africa may be judged by a single fact. In 1850 the area of cultivated land in Egypt was 2,000,000 of acres; in 1874 it was 5,000,000.

I may next refer to the numerous explorations around and across the great continent of Australia from Sturt's early journey to the last ones of Warburton and Forster. The survey of large portions of the coast of Papua or New Guinea, and explorations in the interior by Beccaria, D'Albertis, Meyer, Van Rosenberg, and MacLeay. The explorations in Formosa by Steere, Le Gendre, and others, and the settlement of colonies and the establishment of governments by the English in New Zealand and the Feejee Islands. The explorations of the Arctic to within sight of the eighty-third parallel of north latitude,

including the discovery of the long-sought northwestern passage, and of its inutility. The exploration of the antarctic circle as far as the 73° of south latitude, and the remarkable discovery that the ice-bound regions, both of the Arctic and Antarctic, were, at a former period of the world's history, covered with a luxuriant vegetation, and that plants and animals then existed there in great abundance, which are found now only in the tropics, or in the more southern parts of the temperate zone.

And finally our own explorations of the great Western region, between the Mississippi and the Pacific, by Fremont, Emory, Simpson, Marcy, Stansbury, Sitgreaves, Gunnison, Beckwith, Whipple, Williamson, Parke, Warren, Ives, Reynolds, Macomb, Mullen, Wheeler, and other gallant, efficient, and distinguished military officers conducting reconnoissances or expeditions across its plains, deserts, and mountains, accompanied in these expeditions by scientific civilians, to whose labors we are indebted for our knowledge of its geology, agricultural resources, and natural history. Among strictly scientific works by civilians I should also enumerate Whitney's survey of California, followed by King and Gardner's belt of geological and topographical survey across the North American Cordilleras, Hayden and Gardner's survey in the Rocky Mountains, and Powell and Thompson's of the great cañons of the Colorado, through whose united labors so much of the geography of this vast region has become known; its great mountain-ranges, extraordinary cañons, wonderful geysers, deeply interesting ruins of a prehistoric and semi-civilized people of whom we know but little; its lakes, rivers, majestic cataracts, broad areas of cultivable land, already largely and to be still more extensively settled, and finally the millions it has yielded in gold and silver; a region so vast beyond the one hundredth meridian, that it will be twenty years before we obtain proper maps of it, unless the Government is more liberal in providing for its exploration and survey than it has hitherto been.

To these geographical labors and explorations within this period in various parts of the globe must also be added extensive researches of a geographical character, such as deep-sea dredgings, for the investigation of the temperature of the ocean, the movements of submerged currents, the plant and animal life existing at great depths, and the configuration of the bottom of the seas. The observation and study of oceanic currents and their cause. The distribution of heat north and south of the equator by the instrumentality of these currents, and its effects upon climate, as well as the effect of the currents from polar regions in modifying the heat of the equator. The meteorological observations in respect to the course of the winds; and the investigations of the laws and of the cause of hurricanes, cyclones, and other aërial disturbances. The magnetic observations in elucidation of the difficult subject of terrestrial magnetism. The numerous measure-

ments of great mountain-heights in the more elevated regions of the globe. The extensive survey of coasts, prominent among which is our own great Coast Survey. The trigonometrical surveys carried on in many countries in Europe. The investigation of the cause of the glacial epoch, and possibly of inter-glacial epochs, or a succession of alternate warm and cold periods, each extending over long epochs of time, and their effect in bringing about the present condition of the earth's surface by changes in the level of the sea and the submergence of the land.

This very inadequate statement will show how great, wide-spread, and constant has been the work of exploration and research within the period referred to, and how truly it may be denominated a geographical age.

THE MOLLUSKS OF THE ROCKY MOUNTAINS.

By ERNEST INGERSOLL.

IN the summer of 1874 it was my privilege to accompany one of the parties of the United States Geological Survey of the Territories, of which Dr. F. V. Hayden is chief. The field of operations was the mountainous region of Southern Colorado, and it afforded a good opportunity to examine the natural history of the region traversed.

The mammals of the Rocky Mountains have long been well known, particularly the large game, which, except in the distant portions of the Territory of Colorado, has been greatly depleted by the constant pursuit of hunters and trappers. The case is somewhat the same with the game-birds; while the enthusiastic labors of Henshaw, Aiken, Allen, Coues, and other ornithologists, have given us a very complete knowledge of all the birds and their habitats. The fishes and reptiles have received some attention too; and, in the lower, invertebrate forms of life, the investigations of Thomas upon the grasshoppers, Carpenter on the butterflies and moths, and Edwards, Packard, and Hagen on other insects, and the reports upon crustacea and worms by Verrill, Smith, Leidy and others, have given us a tolerable knowledge of the extent to which those forms are to be found in that region. But the mollusks of the mountains—land-snails, pond-snails, river-snails, and fresh-water mussels—have been almost entirely neglected, except by Dr. Cooper, in the north. From Colorado only seven had been reported, which were collected by Lieutenant Carpenter. This, then, seemed to be the field most needing cultivation, and my attention was chiefly turned to it during three months of wandering over the mountain-ranges, parks, and sterile plains, that diversify the country between Middle Park and the corner of Arizona. Something was found at nearly every camp, and, when the collection was at home and counted, it was

somewhat surprising to find over fifty species, only nine of which had been hitherto known to exist in the Central Province, where an extreme "paucity of species, ... owing to the nature of its climate and soil," had been alleged. Five of these species were new to science, and have since been described in the "Bulletin of the United States Geological Survey," second series, No. 2, which has since been reprinted in an extended and revised form, in the Annual Report of the Survey for 1874.

The Central Province alluded to above is the name given by Mr. W. G. Binney[1] to that portion of the United States embraced between the crests of the Sierra Nevada and Cascade Mountains on the west and the edge of the great plains on the east. It was considered to be unfavorable to the development of pulmonates and deficient in the number of species to be found, and that its fauna was closely allied to that of the Eastern States, whence it had been largely derived by way of the north, where the plains are succeeded by forests and the Rocky Mountains dwindle into hills.

With respect to this distribution of mollusks in Colorado, none were found on the eastern slope of the range, although there is no conclusive evidence that they do not exist there; altitude seemed to have very little influence upon their dispersion, as long as other favorable conditions were present, and some species had a very local distribution.

The eastern slope of the Snowy Range is abrupt, and receives comparatively little rain. Westward of the summit, however, certain genera—as *Zonites*, *Vitrina*, *Vallonia*, *Patula*, *Pupa*, *Succinea*, and *Pisidium*—were everywhere represented. Vitrinas and pupas were, perhaps, the most common forms, the latter being particularly numerous on the Sierras in the southeastern corner of the Territory, where *Pupilla alticola* were traced up to the very limit of timber-growth, and upon the face of precipitous cliffs of volcanic rock, in whose clefts only tufts of grass could gain a foothold. With the latter shell also occurred some small succineas, and a mollusk with a delicate, box-shaped shell, only one-tenth of an inch in diameter. Plenty of these little fellows, as lively as could be, were to be found at the astonishing height of 11,500 feet. They proved to be undescribed, and to belong to the sub-genus *Microphysa*, the two American species of which, heretofore known, are natives of the Gulf coast and the West Indies. Why this species should depart so far from the habits of its congeners as to thrive best in the arctic climate of these mountain-tops, is strange. This *Microphysa* was afterward met with in the valleys south of these Sierras, and in the mountains west of North Park. In this same southern group of mountains many other shells were found—at a lesser altitude, but where water froze every night in August—of the same species as existed in other parts of the Territory,

[1] In the "Bulletin of the Museum of Comparative Zoölogy" (Cambridge, Mass.), vol. iii., No. 9, "Geographical Distribution of North American Mollusca."

and, indeed, all over the Central Province. The finding of *Pupilla Blandi*, heretofore known only as a fossil in Missouri River drift, living and abundant, is an instance worthy of special mention.

It would seem, then, that a range of high mountains, or any number of ranges, would not offer a serious obstacle to the migration of land mollusks, or an insurmountable one to fresh-water forms. The widespread dissemination of such slow-moving creatures is a curious argument for the length of time that the country must have remained in substantially its present condition.

The Sierras of which I have spoken are those which encircle Baker's Park and the San Juan mining region, and extend westward to the base of the great Uncompahgre Mountains, which trend northward not far from the Utah line. This group of volcanic and quartzite peaks constitutes the highest land anywhere in that region, and gives source both to the Rio Grande del Norte and to the head-waters of the Great Colorado River. Its steep southern sides are gashed with tremendous gulches through which the Rio las Animas, the Rio La Plata, the Rio los Mancos, and other streams, which go to make up the Rio San Juan, flow out into the terrible cañon-cut deserts that stretch away across Arizona to the Gila River. For a few miles after emerging from their rocky gates, these rivers water beautiful and fertile valleys, which are cut through the sandstones upturned against the intruded peaks, and which abound in springs. In these valleys are plenty of timber and undergrowth, the climate is rarely cold enough for snow even in winter, and there I expected to gather a rich conchological harvest. In this I was not disappointed, only regretting that I could not make a more thorough examination than was permitted by the rapidity of our travel. Between the Animas and La Plata the trail passes through a valley between the lowest of the foot-hills, where there is a pond of several acres extent, resorted to by all sorts of wild-fowl, inhabited by many forms of amphibious life, and choked with an exuberant aquatic vegetation. Here were found thousands of limneas of several species, and quantities of the common *Planorbis trivolvis* showing a large range of variation among themselves. Like the limneas, the planorbs were extremely fragile in texture, which may be owing partly to the soft bottom, and partly to the scarcity of lime in the water; and they were distinguished by a short vertical diameter, which peculiarity, also, may have been acquired by them from the necessities of their habitat, since snails having shells with small breadth of beam could most advantageously pass between the stalks of standing water-plants that everywhere crowded the pond. But the astonishing fact about this pond was, that on the shore were found perfect specimens—although dead—of the marine genus *Truncatella*, a broken specimen of an *Arca*, and living crabs pronounced by Prof. Sidney I. Smith, of New Haven, to be true salt-water forms belonging to the family *Astacidæ*. That these are survivors of the period, prob-

ably comparatively recent, when here was a soft-water marsh that remained caught in this basin among the hills after the country, for a long distance south of it, had become dry land, seems very evident. It is difficult otherwise to account for their presence.

Farther on, in the valley of the Rio La Plata, where it emerges from its magnificent quartz cañon, and where the gold placer-mines and prospective city of La Plata are situated, a fine collecting-ground was found. This was so far south that many deciduous trees grew in the river-bottoms, and nearly every terrestrial species hitherto met with was there to be had in plenty. For the next ten days we were entirely in the lava-blasted, treeless and waterless deserts on the northern margin of the Rio San Juan, engaged in exploring the vestiges of that ancient semi-civilized race of village Indians, the remnants of which still exist in the small tribe of Moquis on the Little Colorado. During this time no mollusks were found except, where there was a little moisture, a few pupas, which seem able to live anywhere, and many bleached shells of various species that had been drifted down from the mountains at times of high water.

Our return-journey from the San Juan country was made from its very sources along the course of the Rio Grande. It led us through Antelope Park, on the eastern side of which lies St. Mary's Lake, a beautiful little sheet of crystal water studded with islands, and held among precipitous cliffs that afford it no visible outlet. It seems to be merely a great rocky basin, holding the melted snows of the surrounding heights. Its surface is over 9,000 feet above the sea. There existed in countless numbers in this lake a large species of coil-shell which was a nondescript, and which I have since named *Helisoma plexata*. Each of the hundreds of individuals seen possessed in a more or less marked degree a twisted appearance, resulting from a change in the plane of revolution in old age, which is the most striking specific character. This sudden change in the directness of the growth causes the carina of the third whorl to rise into a sharp shoulder on the right side, while on the opposite side the third whorl sinks underneath the overflowing outer whorl. A similar change often occurs in the fourth whorl, giving a braided look to the shell. How this species came almost alone to inhabit this secluded lake is a problem, complicated by the fact that probably there is not another large *Planorbis* within fifty miles. That the wild-fowls, abundant on the lake, brought the eggs clinging to their feet, may be a plausible explanation; but where did they bring them from, and when? The bottom of the lake is, for the most part, rough conglomerate rock, and is in many places filled with tangled water-plants, which may partially account for the peculiarities of the species. The shells of this genus appear to be especially subject to distortion under abnormal conditions.

Continuing our course down the valley of the Rio Grande to the town of Del Norte, we there left the river and struck across the San

Luis Valley to Mosca Pass through the Sangre de Cristo Range. This alkali and sage-brush plain, fifty miles wide, is very far from being "the garden of the world," as it has been styled. Near the eastern side is a group of lakes, the water of which is highly alkaline. These lakes are the abode and breeding-place of wild geese and ducks in the greatest number, which are tormented without end by the gulls that also make the lakes their home. On the gravelly beaches I picked up many shells, and doubtless in the deep water many more species might have been dredged, had there been time. But nowhere were there any bivalves, except the little cyclades. The fact that there was no lack of molluscan life in these intensely bitter waters was not surprising, since mollusks seem to flourish in mineral springs of both hot and cold water everywhere. We had seen before a fine illustration of this adaptation to peculiar conditions. The Grand River, which flows through Middle Park, contains no mollusks at all that I could discover; but at Hot Springs, in a little lagoon filled at high water, large, clear, *ampullacea*-like forms of the familiar *Physa heterostropha* were common. Close by, in the few yards of exposed outlet of the springs of hot sulphur-water from which the locality derives its name, there occurred in the greatest profusion a blackish, globose variety of the same species only one-fifth of an inch long. The temperature of this water was at some points as high as 100° Fahr. In the basin of a still hotter spring not ten feet away, whose waters were saturated with chlorides of sodium and magnesium, hundreds of still smaller *Physæ* were floating about in mats glued together by a tangle of confervoid vegetation and the depositions of the water. All these seemed to have lost their apices by erosion, "which is extremely liable to happen to shells living in water charged with alkaline salts other than lime." On the other hand, quite as small and black were the examples from the pure cold springs near Saguache, where there was seemingly nothing whatever to stunt their growth.

I was stimulated, by the results of my study of my own collection from Colorado, to gather all possible information about the mollusks of the Central Province generally, as it has been limited above. The bibliography was quite large, but the notes of locality and station very meagre. Tabulating the sum of the information open to me, and including my own summer's work, I found that 138 nominal species had been recorded as occurring in this inter-montanic region. Of these, 49 were also Californian species; 15 occurred also in the Eastern United States; 8 hailed from the Colorado Desert; 7 were found all over the continent, and 8 all over the world; and 3 belonged in the Eastern Province, west of the Alleghanies only. This left 47 nominal species, whose range, so far as yet known, is confined to the Central Province. Many of the specific names in this list, however, rest upon very insecure foundations, and will, no doubt, soon be reduced to synonyms. With respect to their vertical distribution, ob-

servations in the Rocky Mountains do not tally well with D'Orbigny's notes from the Andes, since out of 156 species discovered in South America, he found only 13 between the thirty-fourth and forty-fifth parallels of latitude—which corresponds to the district of north latitude considered here—and only 10 species were found above 5,000 feet. My list of the Rocky Mountain mollusca, on the contrary, shows that 55 species out of the 138 inhabit heights exceeding 5,000 feet, and 10 species have been found above 10,000 feet. These latter, however, are all recorded from mountains south of the thirty-ninth parallel; but it is safe to say that, where there is moisture, a goodly collection of mollusks can be made in the mountains of the Territories all the way up to the timber-line. This is probably true of all parts of the world.

In a recent paper on the hypsometric distribution of mollusca in Europe, communicated to the French Academy of Sciences at Paris, at their meeting on October 11, 1875, M. P. Fischer alludes to the great regularity with which plants thrive on mountains, each at a certain height. The terrestrial mollusca, being unprovided with means of locomotion enjoyed by birds and insects, and being, moreover, dependent upon vegetable life for food, could not fail to be discovered in the same way as plants, and this supposition he confirmed by observation. Each species extends to an altitude the limits of which it does not overstep. M. Fischer has verified this in the central Pyrenees as well as in the Alps, and divided the altitudes into five zones, comprised between 1,500 feet and 7,500 feet. Each zone is distinguished by the name of a species of *Helix*. Thus, in the Pyrenees, the first zone, ending at a height of 3,000 feet, is called that of *Helix carthusiana;* the second, ending at 3,600 feet, *Helix aspersa;* the third, terminating at 4,500 feet, *Helix limbata;* the fourth, limited at 6,000 feet, *Helix nemoralis;* and the fifth, ending at 7,500 feet, *Helix carascalensis*. In the Alps, at the same altitudes, the names of the zones are respectively *Helix carthusiana*, *obvoluta*, *Fontenelli*, *sylvatica*, and *glacialis*. A few individual mollusks will, indeed, climb as high as 9,000 feet, but they all stop at the limit of perpetual snow. Various genera of fluviatile mollusks do not ascend higher than 3,000 feet, a circumstance which the author considered of some importance to geologists, since it proves that in the quaternary beds the fossiliferous strata containing those genera, such as *Neritina*, *Paludina*, etc., were deposited at small altitudes. The Lake of Goube, about three hours' walk from Cauterets, 5,364 feet above the level of the sea, is thickly peopled with trout, frogs, and mollusks.

The results of this inquiry into the geographical distribution of mollusks in the mountainous West are meagre enough, but may be of some use in future investigations. Whether this central region is a true zoölogical province considered with reference to the mollusca, and what is the origin of its fauna, are hardly to be answered yet.

Enough seems to be known, however, to show that this inter-montanic region is not so deficient as has been supposed, either in the number of its species or in representatives of adjoining faunas. The impression that the Central Province is unfavorable to pulmonate growth also seems wrong, except in respect to the scarcity of lime in the soil, to which cause we may probably attribute the fact that the more minute forms are in large majority.

CHARACTER AND WORK OF LIEBIG.[1]

By J. L. W. THUDICHUM, M. D.

JUSTUS LIEBIG was born on the 12th of May, 1803, at Darmstadt, in the grand-duchy of Hesse. His father was what in this country (England) we should term a wholesale druggist and dry-salter, a trade which is in Germany designated by the name of materialist. There is no doubt that the opportunities which he had of collecting chemical reagents, and of witnessing the preparation of many products which were the objects of his father's trade, early excited in him that curiosity which soon became an insatiable thirst. It is related on creditable testimony that at the age of fourteen years he had performed all the experiments of which he could get knowledge from books, or for which within his means he could obtain the materials, and it is related by himself that about that time there was not a work in the library of the Grand-duke of Darmstadt on chemistry which he had not read. Looking at his early days by the light of that information, we cannot doubt that the anecdote ordinarily told of his having been a dull boy is a mere mistake. He was abstracted by other pursuits, and therefore, no doubt, neglected his school-work, but that he should have been less gifted than others cannot, under the circumstances, be believed. It is related by a credible person that in 1817, when he and his school-fellows were speaking to each other as to what pursuit they were to select, he said that he was going to be a chemist, whereupon the other boys laughed at him and told him he was a great fool, for a chemist was nothing. However, times have changed, and what at that time was considered as no pursuit is now an honored profession.

In the year 1818 he gave a distinct direction to that early bent of his mind, and he followed almost the only way which at that time existed in Germany for studying chemistry; he became an apprentice in an ordinary apothecary's establishment. An apothecary in Germany is a more scientific person than perhaps many would believe. He has had a thorough training, he has passed examinations, and he represents, therefore, the scientific side of chemistry, pharmacy, and

[1] From the "Cantor Lectures" delivered before the Society of Arts.

the science of drugs in perfection. To such an apothecary, residing at Heppenheim, near Darmstadt, Liebig went, and remained there about ten months, but in that occupation as an apprentice his mind soon became wearied, he saw that he could not attain his object; and when, while continuing some of his early experiments on the fulminates, on one occasion he had the misfortune to produce a great explosion, this fact quickly terminated his apprenticeship, and he returned to Darmstadt. These explosions in the early days of great chemists are not uncommon. It is related in the case of Scheele that, when he was apprenticed to an apothecary, he once had a great explosion, in consequence of which his landlady expelled him from the house.

Liebig returned to his father's house in the year 1814, and read for six months in order to prepare himself for visiting the University of Bonn. He there listened to the lectures on theoretical chemistry of the well-known Prof. Kastner, and he also studied the other natural sciences and some languages, and, what is very characteristic of his great genius and perseverance, he formed a society among the students for the purpose of teaching one another, and for discussing subjects connected with chemistry and physics. Kastner being called to Erlangen, Liebig followed him there, and we are told that there he read all the new chemical publications, established another students' society for the same object as the first, and made many friends among the students, of whom several continued that friendship up to their death. Thus the celebrated poet, Count Platen, corresponded with him to the time of his death in 1830, and of this friendship we can see many congenial influences in the writings of Liebig, for there is no doubt that, in his "Familiar Letters on Chemistry," the language, although always prose, frequently rises to the highest beauty, such as can only be produced by a mind of a poetical turn. The same influence of the classical period of German literature you will also perceive for example in the writings of Humboldt, particularly in his "Views on Nature," which are therefore considered as examples of classical German diction. Liebig also made the acquaintance of Bischof, the botanist, and of Engelhard, later Professor of Chemistry at Nuremberg. He went in for the severe study of what at that time was called philosophy, that is, he listened to the lectures on metaphysics and philosophy in general, of the then great Schelling. Now, let me give you the words of Liebig on that period of his life. He says: "I myself studied for some time in a university where the greatest philosophers and metaphysicians of the century carried the studying youths away to admiration and imitation. Who could at that time resist the infection? I, too, have lived and participated in this period so rich in words and ideas, so poor in true knowledge and solid studies: it has robbed me of two precious years of my life. I cannot describe the terror and dismay which I felt when I awoke from this giddy dream to consciousness. How many most gifted and talented men

have I seen perish in this vertigo, how many wails about life-objects completely missed have I been obliged to hear afterward!" Thus he spoke in his work on the study of the natural sciences, which was published at Brunswick in 1840.

Now, in order that you may be able to apprehend what this kind of philosophy was, and to understand more fully the position from which he had to emancipate himself, even at that early time of his life, I will quote to you a very few passages, and I will make them as short as possible, compatible with illustration, from one of Schelling's works, from the periodical for speculative physics—mark the term, "Speculative Physics." I will quote the following passage: "Nature strives in the dynamical sphere necessarily to absolute indifference, not by magnetism nor by electricity is represented the totality of the dynamical process, but only by the chemical process. With the third dimension of the product the two other dimensions are opposed. In Nature itself there is one and inseparate, what is separated for the purpose of speculation." That is almost enough, but I will give you another passage which will be more striking because of the contrary itself being known to you. Here he says of the composition of water: "Water contains just the same as iron, but in absolute indifference as yonder in relative indifference, carbon and nitrogen, and thus all true polarity of the earth is reduced to an original south and north which are fixed in the magnet." Now, in order that you may believe that he did not merely speak of an admixture or impurity of carbon or nitrogen, but that he meant to say that it was the essence of water, and that it was really composed of these two elements, and not of any other, he goes on to say: "The animal is in organic Nature the iron; the plant is the water, for Nature begins with the relative separation of the sexes, and then ends in this separation. The animal decomposes the iron, the plant decomposes the water. The female and the male sex of the plant is the carbon and the nitrogen of the water." These are two examples of the philosophy of Schelling, which was believed at that time to be the science by which Germany could be regenerated, by which the generation which had then only just recovered its independence would be put on a firm mental basis. The followers of this system were called to the court of Prussia, and there Hegel, the philosopher, continued in a similar manner to teach doctrines which nowadays seem to be but a *farrago* of nonsense. Hegel says, for example, on the chemical process: "If electricity was the broken magnetism, because the opposite poles are independent bodies upon which the positive and negative electricity is distributed, and if the point of indifference is the explosion of an indifferent light by itself, then is the chemical process, on the other hand, the totality of the shaping. We have two independent bodies which belong more to the one or the other extreme; to the metal on the one hand, or the sulphur on the other, which meet in an indifferent medium, and by abandoning their

abstract one-sidedness in which they decompose the medium combine to a third body which is the totality and the neutrality of the opposites, the dynamical process in its highest perfection."

When a young man of seventeen or eighteen years of age is capable of freeing himself from the trammels of such a chimera termed philosophy, which had taken such a deep hold of a whole nation as to cause to flock to the university where it was taught the selected youth of the whole country, you may give him credit for great power of mind and for great independence of judgment. Do not forget that this development of the philosophy of Schelling and Hegel was a consequence of the latter part of the philosophy of Kant. Kant's philosophy was great as long as it was based on the exact sciences, upon physics, and upon mathematics, but when he left that basis and went into the speculative philosophy he gradually went away from that basis which had made his early philosophy so sound and so full of meaning for the perfection of the human understanding. On the other hand, when you come to a further development of the same philosophy, namely, that of Fichte, there the speculative part vanishes entirely into insignificance, because that which Fichte taught was not such kind of nonsense as that which I have read to you, but it was a kind of moral philosophy which spoke to the youth of Germany, and taught them this one great proposition, which every one of them ought to feel, and which is the first condition of self-consciousness in man, namely, "I am I;" this was the great teaching of Fichte, by which he brought home to men their own value and their own powers, which cannot be said was the result of the other philosophy from which I have quoted.

In 1822 Liebig, having emancipated himself from this kind of teaching, took the degree of Doctor of Philosophy at Erlangen, when he was nineteen years old. In the autumn of that year he returned to Darmstadt; his researches and endeavors then became known, and he attracted the attention of the Grand-duke Ludwig I., of Hesse-Darmstadt, who conferred upon him a state stipend, to enable him to continue his studies at Paris. To Paris, therefore, he went. Now let us for a moment consider what was then the condition of chemistry at Paris. Lavoisier, the great reformer, who had established what was then called the antiphlogistic chemistry, had thirty years before died on the scaffold; Guyton de Morveau, Fourcroy, and Berthollet, whom the first Napoleon called the *plus brave des Français*, because he gave him chlorate of potassium, by which he hoped to overcome the want of nitre for his gunpowder; the great Société d'Arcueil, which worked through the whole of the war-times zealously at science, and published its memoirs—all these men had passed away. But there remained their disciples in the persons of Proust, Chevreul, Vauquelin, Gay-Lussac, Thénard, and Dulong. Chevreul is the only one of these celebrated men who now lives, and he has lately published, in the

Comptes Rendus, a very remarkable paper on the changes which are produced in the power of thinking and observing by age. Fourcroy, the great animal chemist, who, in connection with Vauquelin, laid the foundation of that physiological chemistry on which the modern science is based; then Gay-Lussac, Thénard, and Dulong, men of the new science, who continued the work in a most glorious manner, which in this country had been carried to such a glorious issue by Humphry Davy—these men were at that time teaching at Paris, and at the laboratory which the liberality of the first Napoleon and his envy of English discoveries had established at *L'École Polytechnique*. They contiued to study and shape the new science which was destined to give to the modern science of chemistry precision.

Liebig then worked with Thénard, listened to Gay-Lussac's lectures, and he met there the young German chemists, Runge, well known by his many researches on tar, and the tar products; Mitscherlich, the discoverer of isomorphism and polymorphism; Gustav Rose, the representative of the perfection of analytical and inorganic chemistry. In 1823 he brought his first paper on the fulminates of silver and mercury before the Academy. And now, let me quote to you what he says of that event in the first work which he ever published. In the preface, which is a dedication to Alexander von Humboldt, he says that at the meeting of the Academy, on the 28th of July, 1823, he had read his paper, and was just engaged in packing up his apparatus and preparations, when a man, one of the members of the Academy, approached him, entered into conversation with him, and in an incredibly short space of time knew how to elicit from him all his hopes, schemes, and intentions. He did not dare to ask, either from shyness or from accident, who the gentleman was who spoke to him, and he disappeared again among the academicians. But he says: "From that day all the doors of society, and of all institutions, were open to me. I did not know until many years afterward to whom I owed this introduction and favor." It was to Humboldt, who had so well recommended him to the great French chemists that Gay-Lussac, who never took any pupil whatever into his laboratory, accepted him as his only pupil, and, more than that, joined with him in his continuation of those researches which at that early age he had brought to such perfection. This preface is beautiful in its conception and feeling, and has been printed in all the seven editions of the work which have since been published. If there were time this would, perhaps, be the place to show the wonderful influence which Humboldt has exercised upon the science of all countries; but I must pass over that subject, and continue the account of Liebig's life.

Through the recommendations of Humboldt and Gay-Lussac, both of which were addressed directly to the Grand-duke of Hesse-Darmstadt, Liebig was, at the age of twenty-one years, by the supreme will and absolute power of the grand-duke, appointed first Professor of

Chemistry in the University of Giessen. A new chair was established for him, and as a laboratory he received a room, as he expresses it, with four walls. Great was the opposition against this new professor; for what was chemistry? Chemistry was no science, nobody knew anything of chemistry, nobody would have it. Moreover, the appointment had not been made in the regular way, therefore the whole of the authorities of the university set themselves against it. The consequence was that the majority of that university persecuted that man for twenty-seven years; and, no matter what was his reputation, the amount of his work, or the importance of his position, for twenty-seven years this man could never once be made Rector of the University of Giessen. But where are the opposing influences now? History will not mention their names. Their ultramontane participators tried to decry the great man as an atheist and materialist, and by that means to remove from him the assistance of the state, and to diminish his chance of gaining a living. But he was too strong for all of them. In the year 1826 he was appointed Professor in Ordinary, a promotion by which he became a fixed servant of the state and a fixed member of the university. In that year he married Henrietta Moldenhauer, a most amiable lady, who now survives him.

Now comes the period of work which lasted to the year 1834. The work itself I will not now enter upon, but we will, in future lectures, see what was the nature of that work. We will perform before your eyes some of those operations by which that work has become of the utmost importance to mankind at large; and you can then see how, from a small point, there can be a light shed upon the largest problems of science.

In this year 1834, however, Liebig fell ill from overwork and anxiety. A portrait, which was taken at that time by the now deceased painter Engel, gives evidence of that, and I remember that the late Prof. Zamminer told me that he had seen Liebig about that time taking short walks in the evening air, looking pale and haggard, like a man in consumption, with little spots of hectic on his cheeks, and that his friends were afraid he would soon die. At that time he retired from Giessen for a while, and went to Baden-Baden, in the hope of recruiting his health. The patience which he had exercised for many years, under the most narrow arrangements, then gave way, and he asked for the building of a new lecture-room, the arrangement of a proper laboratory, and for an increase of salary. All was refused by the narrow-minded Government of Hesse-Darmstadt, through that close-minded man, the then chancellor, Von Linde. Then Liebig wrote to Von Linde a letter, in which, after the introduction, he continues thus:

"I should have gained some convenience by these arrangements, but they were not intended for me personally; they would have been of lasting value for the university, and would have secured to the chemical chair an advantage over

all others in Germany. For the institutions of a university the largest sums may be expended, for this increases the respect and affection for them; but the suitable employment of these sums must be strictly controlled. The sums are there, but they are used in an intolerably ridiculous manner. I must be certain of what I may have to expect at Giessen. If driven to extremities I shall not return there this winter, whether I obtain leave or not. I shall know how to justify this step, for no one has been maltreated in the university in a more conspicuous manner. One cannot live at Giessen upon a salary of 800 florins. Four years ago I, in conjunction with four colleagues, asked for an increase of salary; it has been refused. You (the Chancellor von Linde) have assured me with smiles that the state treasury had no funds; from this I saw that you have never known grief and torturing care for the daily bread. From the moment of that refusal I have endeavored to acquire an independent position by ceaseless work; my exertions have not been without success, but they have surpassed my strength, and I have become an invalid; and if now, when I do not require the state any longer, I consider that with a few miserable hundred florins more my health need not have suffered in former years, because my life would have been more free from care, the hardest thought for me is that my situation was known to you. The means which the laboratory possesses have been too small from the beginning. I had four walls given to me instead of a furnished laboratory. Notwithstanding my requests, no sum for furnishing the same, or for buying apparatus, has been provided. I required instruments and specimens, and have been obliged to spend on these items annually from 300 to 400 florins from my own means; besides the *famulus* paid by the state I required an assistant, who costs me 320 florins—deduct both expenses from my salary, and there remains not enough to clothe my children. From this original treatment of the laboratory the consequence has arisen that it possesses no property, for I can show that the arrangements, fittings, instruments, specimens, which have made the Giessen laboratory—I can say it without blushing—the first in Germany, are my property. I will say nothing more about myself—my account with Giessen is closed. My path is not the one of reptiles, the easiest though the dirtiest. What I have said will suffice to justify with the ministry and the prince my resolution not to lecture at Giessen during this winter (1834–'35). If I am in health I may not lack the power to establish a kind of university for my branches of science at my own risk. If I am not permitted, and if I receive my *congé*, this will free me from the charge of ingratitude toward the country from the means of which my scientific training has been possible. I have learned to bear much injustice, many a false judgment, but this reproach of ingratitude would be too heavy for me to bear."

This letter pictures to you the conditions which prevailed at Darmstadt, but it is still more important, because it shows that such strong language was required to bring down the ministry, and that which no kind of friendly representation had been able to effect, this threat did. In 1835 he had to take compulsory repose. I find in the list of his publications only three small papers dating from this period, of which one only was a research; but in almost every other year there were from ten to twenty researches and publications.

In 1836 another active period begins. In that year there were nine researches by himself alone, thirteen by himself and Pelouze. In 1837 there were nine researches by himself and five with Wöhler, in-

cluding the celebrated one on lithic acid, and two with the celebrated French chemist Dumas. In that year the British Association for the Advancement of Science, at their Liverpool meeting, made a request to him to write a report on the then state of knowledge of organic chemistry. It was this report which originated the work which he published in 1840, namely, the work entitled "Organic Chemistry in its Application to Agriculture and Physiology." In 1838 he published a memoir on the state of chemistry in Austria, in which he exhibited its shortcomings in trenchant language, and the effect upon the Austrian Government was such as no one would have expected. In reply to his essay he received the offer of a chair at Vienna. "Come to us," they said, "reform our chemistry, and we will give you a chair." But the conditions were not sufficient, and the Austrian Government, having received Liebig's refusal to go to Vienna, at their own expense sent a number of young chemists to Giessen, there to study chemistry under Liebig, and to prepare themselves for the important function of becoming teachers of the new chemistry in Austria. In the year 1840 he published the work which I have already mentioned, and he also published a memoir on the state of chemistry in Prussia. You know what was the state of Prussia in 1840; the promises made by the king in the year 1813, regarding a liberal constitution, had all been falsified, a narrow-minded bureaucracy governed everything, a minister of education who did not comprehend his time could not understand that physical science required any promotion, or any state help. He soon went into that movement which has been described as *Muckerthum*, a kind of pietism which shows itself by casting up the eyes in a praying attitude, having God more on the tongue than in the heart; by a mock-modest morality which would, for example, have caused the council of this institution to have those beautiful nymphs on our walls painted over with drapery. Under these circumstances no science could progress, and there was not in the whole of Prussia a single establishment, laboratory, or teaching-room where a man could learn practical or even theoretical chemistry. It was the great boast of even talented teachers of chemistry, that all the apparatus they required for teaching was a dozen test-tubes. This attack on the state of chemistry in Prussia had no effect whatever of a good kind, but, on the contrary, the bureaucracy used its power and influence to prevent the Prussian youth from visiting the University of Giessen, and I have the authority of Kolbe that for a time the visiting this university was actually forbidden to young Prussians.

About this period Liebig purchased from the municipality of Giessen a sand-pit, at a place called Trieb, on a little height east of the town, and there he made experiments on vegetable physiology. This place bears the name of "Liebig's Height" to the present day, and I dare say it will bear it for many years to come. He also pub-

lished his work on "Chemistry in its Application to Physiology and Pathology," which he dedicated to Berzelius. In 1844 appeared his first "Familiar Letters on Chemistry," in the *Augsburg Gazette*. These letters were afterward published with many new ones from time to time in several editions, and by this means he contributed greatly to make chemistry popular, while still keeping it in the most scientific form needful. In 1850 he published a pamphlet on spontaneous combustion, on the occasion of the death of the Countess Görlitz, who had by experts and doctors at Darmstadt and Giessen been declared to have perished from spontaneous combustion, but it was afterward found out that she had not perished in that way, but that she had been murdered by her butler, and afterward burnt. About this time also Liebig effected a reform in the medical studies and examinations in the University of Giessen, and this reform was so important, and effected by so great a participation of public opinion, that we see there how great was his power, although in the university itself he was kept out of office as far as possible. These reforms amounted to nothing less than this—complete liberty of study. You know that in this country medical students have no liberty of study; they are obliged to attend lectures, to have heard at least two-thirds of the lectures given, and if it is not certified by the beadle, who comes in to every lecture and takes the names of all present, that they have been present at two-thirds of the lectures, they are not allowed to enter for the examination. This state of things also existed in the German universities previous to this reformation. At that time, however, this was completely done away with, and every student was allowed to obtain his knowledge where and how he pleased. He was not obliged to enter any university whatever, but he was obliged to pass an examination, and to pass that examination publicly, an examination which should so thoroughly test his knowledge that, after he had passed it there could be no doubt whatever about his fitness to follow his profession. Now let me recommend to your attention this most remarkable system of public examination. The extraordinary effect it had on the University of Giessen was this, that, whereas formerly many students coming unprepared were rejected, since the introduction of public examinations few rejections have taken place, because the students take great care to get up their subjects and to come so fully prepared that, in the presence of their countrymen, in the presence of any person who likes to enter the hall when the examination takes place, they can show that they are fit to follow their profession.

I have already, I see, passed the time allotted to me, and I shall not detain you many more minutes. In the autumn of the year 1852 Liebig left Giessen, having received a call to the University of Munich, where the then King Maximilian was desirous of following his father, Ludwig, on another path of glory. You know that Ludwig had made it his life-business to restore art in Germany and raise it to

a high footing in Bavaria, and Maximilian now wished to do the same thing for science in general, and he therefore endeavored to collect from all parts of Germany the best men whom he could attract. One of these was Liebig, the king having made him president of the Academy, with the condition that he should undertake no laboratory teaching; that he should deliver lectures only, and at the same time be the Curator of the Botanical Gardens. In that position he remained up to his death, devoting himself mainly to the public part of his duties, which he performed with grace, honor, and glory, and in the laboratory which had been constructed for his own immediate wants he only performed such analyses, partly himself, and partly by a number of assistants, as were necessary to give him the data for the publication of his several works.

At last, in the year 1873, on April 18th, he died, nearly seventy years of age, and in full possession of his faculties, not having, as other philosophers have had the pain of doing, experienced any diminution of his mental powers.

CAROLINE LUCRETIA HERSCHEL.

By ELIZA A. YOUMANS.

II.

WHATEVER may be thought of the intellectual differences between men and women, the broad mental contrast between Caroline Herschal and her brother Sir William Herschel is undeniable. Intellectual activity and a love of knowledge for its own sake influenced his boyhood, characterized his manhood, and dominated his whole life. He became an eminent astronomer because his passion for physical inquiry, directed toward the constitution of the universe, mastered every other sentiment of his nature. But the mind of Caroline Herschel was of another mould. She learned various things, from a desire to please her friends and to earn her living; but there is no evidence that she ever studied anything from a love of knowledge. Her whole life was inspired by purely personal feelings. In a former article we saw how submissively she delved for the family throughout her youth, and left them full of concern about their daily comforts. It was an all-absorbing love for her brother which led her to study astronomy, and at his death her devotion to science ended. Some people, perhaps, will admire her less on this account; yet, while it diminishes her claims as a philosopher, it certainly increases her claims as a woman. The tendency of women to act from intense personal motives is a fact of vital moment to the community, because the very existence of the family depends upon it; and it is difficult to imagine any future

phase of society, of which the family is a factor, where engrossing personal feeling will not continue to be a supreme womanly trait.

Resuming our history, we find that on the 1st of August, 1782, the Herschels with their instruments and furniture arrived at Datchet, and took possession of a large and neglected old house, with garden and grounds overgrown with weeds. Having no female servant, Miss Herschel was shown the shops by the gardener's wife, and her practical sense was at once shocked at the prices of everything, from coal to butcher's meat. But her brother was not disturbed by such considerations. He had stables where he could grind mirrors, a roomy laundry for a library, a large grass-plot for his instruments, and "he gayly assured her that they could live on eggs and bacon, which would cost nothing to speak of, now they were really in the country." After a couple of months the younger brother went back to Bath to resume his occupations in music; and it was this separation which awakened Caroline to a consciousness of what she was doing in giving up the prospect of becoming independent in the musical profession. But she reconciled herself to the situation by the thought that her brother William could not do without her, and that she had not spirit enough to throw herself upon the public without his protection. Soon after Alexander's departure, William had to go away for a week or ten days, and she was left alone. She thus describes her feelings in entering upon her new work:

"In my brother's absence from home, I was, of course, left solely to amuse myself with my own thoughts, which were anything but cheerful. I found I was to be trained for an assistant astronomer, and, by way of encouragement, a telescope adapted for 'sweeping,' consisting of a tube with two glasses, such as are commonly used in a 'finder,' was given me. I was 'to sweep for comets,' and I see by my journal that I began August 22, 1782, to write down and describe all remarkable appearances I saw in my 'sweeps,' which were horizontal. But it was not till the last two months of the same year that I felt the least encouragement to spend the starlight nights on a grass-plot covered with dew or hoar-frost, without a human being near enough to be within call; for I knew too little of the real heavens to be able to point out every object so as to find it again without losing too much time by consulting the atlas. But all these troubles were removed when I knew my brother to be at no great distance, making observations with his various instruments on double stars, planets, etc., and I could have his assistance immediately when I found a nebula, or cluster of stars, of which I intended to give a catalogue; but, at the end of 1783, I had only marked fourteen, when my sweeping was interrupted by being employed to write down my brother's observations with the large twenty-foot. I had, however, the comfort to see that my brother was satisfied with my endeavors to assist him when he wanted another person, either to run to the clocks, write down a memorandum, fetch and carry instruments, or measure the ground with poles, etc., of which something of the kind every moment would occur."

The summer months of 1783 were spent in getting the large twenty-foot ready for the next winter. After some account of her brother's many and incessant occupations, she says he also threw away some

trouble in the effort to teach her to remeasure double stars with the micrometers used in former measurements, and a small twenty-foot was given her for the purpose. She had also to use a borrowed transit-instrument to find their places, but after many failures it was seen that the instrument was as much in fault as herself. She thus continues her account of her experiences:

"July 8th (1783) I began to use the Newtonian small sweeper, but it could hardly be expected that I should meet with any comets in the part of the heavens where I swept, for I generally chose my situation by the side of my brother's instrument, that I might be ready to run to the clock or write down memorandums. In the beginning of December I became entirely attached to the writing-desk, and had seldom an opportunity after that time of using my newly-acquired instrument. My brother began his series of sweeps when the instrument was yet in a very unfinished state, and my feelings were not very comfortable when every moment I was alarmed by a crack or fall, knowing him to be elevated fifteen feet or more on a temporary cross-beam instead of a safe gallery. The ladders had not even their braces at the bottom; and one night, in a very high wind, he had hardly touched the ground before the whole apparatus came down. Some laboring-men were called up to help in extricating the mirror, which was fortunately uninjured; but much work was cut out for carpenters next day. That my fears of danger and accidents were not wholly imaginary, I had an unlucky proof on the night of the 31st of December. The evening had been cloudy, but about ten o'clock a few stars became visible, and in the greatest hurry all was got ready for observing. My brother, at the front of the telescope, directed me to make some alteration in the lateral motion, which was done by machinery, on which the point of support of the tube and mirror rested. At each end of the machine or trough was an iron hook, such as butchers use for hanging their joints upon, and, having to run in the dark on ground covered a foot deep with melting snow, I fell on one of these hooks, which entered my right leg above the knee. My brother's call, 'Make haste!' I could only answer by a pitiful cry, 'I am hooked!' He and the workmen were instantly with me, but they could not lift me without leaving nearly two ounces of my flesh behind. The workman's wife was called, but was afraid to do anything, and I was obliged to be my own surgeon by applying aquabusade and tying a kerchief about it for some days, till Dr. Lind, hearing of my accident, brought me ointment and lint, and told me how to use them. At the end of six weeks I began to have some fears about my poor limb, and asked again for Dr. Lind's opinion; he said if a soldier had met with such a hurt he would have been entitled to six weeks' nursing in a hospital. I had, however, the comfort to know that my brother was no loser through this accident, for the remainder of the night was cloudy, and several nights afterward afforded only a few short intervals favorable for sweeping, and, until the 16th of January, there was no necessity for my exposing myself for a whole night to the severity of the season. I could give a pretty long list of accidents which were near proving fatal to my brother as well as myself."

Her account of the years 1784 and 1785 is varied by reminiscences of the trouble her brother had in trying to live and pursue his astronomical observations on £200 a year. The book contains many incidental allusions to royal patronage that are not flattering; but, notwithstanding the silence of her diary upon so many matters of real

consequence, she always chronicles the attentions bestowed upon her brother and herself by kings and nobles. Most of her brother's time was spent in making and selling telescopes for other observers, instead of finishing a thirty or forty foot instrument for his own use, upon which his heart was set. The king ordered many seven-foot and four ten-foot telescopes, one of which was to be sent as a present to the observatory at Göttingen. Meantime, through the influence of Sir Joseph Banks, £2,000 had been granted to Herschel, to enable him to make an instrument for himself. After living in Datchet four years, they moved to Slough, in April, 1786, and it was here that Herschel put up his famous telescope, and fixed his residence for the rest of his life.

Sir William Herschel's Forty-foot Telescope at Slough.

In July of this year he went to Germany to deliver the ten-foot telescope from the king, leaving Caroline in charge of matters at home. The stand for the forty-foot telescope was finished, and he left a smith at work on the tube. The mirror was also pretty far advanced. During this absence of her brother Miss Herschel discovered her first

comet. Her diary and letters belonging to this period are very interesting. Her brother left on the 3d, and on that day she cleaned and put the polishing-room in order, made the gardener clear the work-yard, and mend the fences. "*5th.*—Spent the morning in needlework . . . ." "*6th.*—Put the philosophical letters in order, and the collection of each year in a separate corner . . . ." "*12th.*—Put paper in press for a register . . . ." "*18th.*—Spent the day in ruling paper for the register, except that at breakfast I cut out ruffles for shirts . . . ." "*29th.*—I paid the smith . . . ."

It was on the 1st of August that she first saw the comet. We give her diary at this time in full:

"*August 1st.*—I have counted 100 nebulæ to-day; and this evening I saw an object which, I believe, to-morrow night will prove to be a comet.

"*2d.*—To-day I calculated 150 nebulæ. I fear it will not be clear to-night. It has been raining throughout the whole day, but seems now to clear up a little. *One o'clock.*—The object of last night *is a comet.*

"*3d.*—I did not go to rest till I had wrote to Dr. Blagden and Mr. Aubert, to announce the comet."

In the letter to Dr. Blagden she says:

"The employment of writing down the observations when my brother uses the twenty-foot reflector does not often allow me time to look at the heavens; but, as he is now on a visit to Germany, I have taken the opportunity to sweep in the neighborhood of the sun in search of comets; and last night, the 1st of August, about ten o'clock, I found an object very much resembling in color and brightness the 27 nebulæ of the *Connoissance des Temps*, with the difference, however, of being round. I suspected it to be a comet; but, a haziness coming on, it was not possible to satisfy myself as to its motion till this evening."

After describing the object and its position, she concludes:

"You will do me the favor of communicating these observations to my brother's astronomical friends."

Dr. Blagden replied on August 5th that no one but herself had yet seen the comet, but that he had spread the news of her discovery in England, France, and Germany. August 7th Mr. Aubert wrote to her that he did not find the comet till the 5th on account of cloudy weather. He says:

"I wish you joy most sincerely on the discovery. I am more pleased than you can well conceive that *you* have made it, and I think I see your *wonderfully clever* and *wonderfully amiable* brother, upon the news of it, shed a tear of joy. You have immortalized your name, and you deserve such a reward for your assiduity in the business of astronomy, and for your love for so celebrated and deserving a brother."

We give place to the friendly expressions of these gentlemen, and others that will follow, to show that Miss Herschel was not hindered in her scientific career by the jealousy or antagonism of male rivals,

of which ambitious women complain so much in these degenerate days. She continues the diary of her labors:

"*4th.*—I wrote to Hanover; booked my observations; made accounts. The night is cloudy.

"*5th.*—Calculated nebulæ all day. The night was tolerably fine, and I saw the comet.

"*6th.*—I booked my observations of last night. Received a letter from Dr. Blagden in the morning, and in the evening Sir J. Banks, Lord Palmerston, and Dr. Blagden, came and saw the comet. The evening was very fine.

"*7th and 8th.*—Booked my observations. On the 8th the evening was cloudy.

"*9th.*—I calculated 100 nebulæ.

"*10th.*—Calculated 100 nebulæ. The smith borrowed a guinea.

"*11th.*—I completed, to-day, the catalogue of the first thousand.

"*13th.*—Prof. Kratzensteine, from Copenhagen, was here to-day. In the evening I saw the comet, and swept.

"*14th.*—I calculated 140 nebulæ to-day, which brought me up to the last-discovered nebulæ, and therefore the work is finished."

Miss Herschel says it is impossible for her to give an account of all that passed around her in the following two years, for they were spent in a perfect chaos of business.

But in 1788, after he was fifty years old, her brother married a wealthy widow, of about the same age as Miss Herschel. It is said by the editor that the wife was very amiable and gentle, and that the jointure she brought enabled her husband to pursue his scientific career without anxiety about expenses. But this was evidently not so. We must infer from the statements of Miss Herschel that this wealth, like royal patronage, was not applied to relieve Sir William from drudgery; for, to the end of her brother's life, she complains that, instead of pursuing original investigations, he had to spend an enormous amount of time and labor making and selling telescopes; and that the fatigue and exhaustion from polishing mirrors told seriously upon his health. In 1805, more than a dozen years after his marriage, we hear of his finishing an instrument for the King of Spain, and at about the same time another for the Prince of Canino. She further says that he was miserably stinted for room for his instruments, and continually bemoans the embarrassments and hinderances which defeated his plans of study, and asserts that, during the last years of his life, his spirits were depressed and his temper soured by these circumstances.

In her diary, all that Miss Herschel says of her brother's marriage is this:

"It may easily be supposed that I must have been fully employed (besides minding the heavens) to prepare everything as well as I could against the time I was to give up the place of housekeeper on the 8th of May."

When, in after-years, she was preparing the materials for her biog-

raphy, which were to be sent to Sir John Herschel, the son of this new sister-in-law, she destroyed all her diary and records for the ten years immediately succeeding her brother's marriage. Her biographer and relative alludes to her experiences at this time in the following language:

"With saddened heart but unflagging determination she continued to work for her brother, but saw his domestic happiness pass into other keeping. It is not to be supposed, however, that a nature so strong and a heart so affectionate should accept the new state of things without much and bitter suffering. To resign the supreme place by her brother's side, which she had filled for sixteen years with such hearty devotion, could not be otherwise than painful in any case; but how much more so in this, where equal devotion to the same pursuit must have made identity of interest and purpose as complete as it is rare! One who could both feel and express herself so strongly was not likely to fall into her new place without some outward expression of what it cost her—tradition confirms the assumption—and it is easy to understand how this long, significant silence is due to the light of later wisdom and calmer judgment which counseled the destruction of all record of what was likely to be painful to survivors."

In reference to Herschel's marriage, a writer in the London *Examiner* says, "It is impossible to regret or censure the step which gave existence to his yet more remarkable son;" but this is a singular and tardy justification. In marrying, he did what it was highly probable he would do; and, remembering this, he should not have allowed his sister to live so entirely for him. It is not to be supposed, however, that he foresaw the unpleasant consequences that fell upon her. When the temptation to marry came, he no doubt stupidly fancied that in enriching his own life by this new relation he should add to her happiness by bringing her a sister; but, if he had studied the ways of men and women as he studied the heavens, he might have saved himself from such a delusion.

The work she did during the next ten years affords abundant evidence of the heroism with which Miss Herschel met her fate. Besides discovering seven more comets, she prepared "A Catalogue of 860 Stars observed by Flamstead, but not included in the British Catalogue," and "A General Index of Reference to Every Observation of Every Star in the above-mentioned British Catalogue," both of which works were published by the Royal Society in 1798. She also spent much time upon another work which was not finished for many years. It was "The Reduction and Arrangement in the Form of a Catalogue, in Zones, of all the Star-Clusters and Nebulæ observed by Sir W. Herschel in his Sweeps." For this she received the gold medal of the Royal Astronomical Society in 1828, and it was pronounced by Sir David Brewster "a work of immense labor."

Some account of her discoveries was found in a packet wrapped in coarse paper, and labeled "This is what I call the bills and receipts of my comets." The separate parcels of this bundle were marked

"First Comet," "Second Comet," etc. She announced the discovery of her second comet to Dr. Maskelyne, the royal astronomer, in the following letter, with a postscript by her brother:

"DEAR SIR: Last night, December 21st, at 7ʰ 45′, I discovered a comet, a little more than one degree south, preceding β Lyræ. This morning, between five and six, I saw it again, when it appeared to have moved about a quarter of a degree toward δ of the same constellation. I beg the favor of you to take it under your protection.

"Mrs. Herschel and my brothers join with me in compliments to Mrs. Maskelyne and yourself, and I have the honor to remain,

"Dear sir, your most obliged, humble servant,

"CAROLINE HERSCHEL.

"SLOUGH, *December* 22, 1788."

"P. S.—The comet precedes β Lyræ 7′ 5″ in time, and is in the parallel of the small star (β being double). *See* fifth class, third star, of my catalogue.

"WILLIAM HERSCHEL."

Her brother announced her discovery to Sir J. Banks and Sir H. Englefield, and from these gentlemen she received the most cordial congratulations. Two years later, on January 7, 1790, the third comet was discovered, and on the 17th of April, the same year, when her brother was absent, she announced her fourth comet to Sir Joseph Banks in the following words:

"*April* 19*th*.

"SIR: I am very unwilling to trouble you with incomplete observations, and for that reason did not acquaint you yesterday with the discovery of a comet. I wrote an account of it to Dr. Maskelyne and Mr. Aubert, in hopes that one of them would furnish me with the means of pointing it out in a proper manner. But as several days may pass before my letters are answered, or my brother returns, I would not be thought neglectful, and if you think the following description sufficient, and that more of my brother's astronomical friends should be made acquainted with it, I should be very happy if you would be so kind as to do it for the sake of astronomy."

Then follows an account of the comet. The letter, written on the day previous, to Mr. Aubert, we give entire:

"SLOUGH, *April* 18, 1790.

"DEAR SIR: I am almost ashamed to write you, because I never think of doing so but when I am in distress. I found, last night, at 16ʰ 24′, sidereal time, a comet, and do not know what to do with it, for my new sweeper is not half finished; and, besides, I broke the handle of the perpendicular motion in my brother's absence (who is on a little tour in Yorkshire). He furnished me to that instrument a rhomboides, but the wires are too thin, and I have no means for illuminating them. All my hopes were that I should find nothing to make me feel the want of these things in his absence; but, as it happens, here is an object in a place where there is no nebula, or anything which could look like a comet, and I would be much obliged to you, sir, if you would look at the place where the annexed eye-draft will direct you to. My brother has swept that part of the heavens, and has many nebulæ there, but none which I must expect to see with my instrument. I will not write to Sir J. Banks or Dr. Maskelyne,

or anybody, till you, sir, have seen it; but if you could, without much trouble, give my best respects, and that part of this letter which points out the place of the comet, to Mr. Wollaston, you would make me very happy.

"I am, dear sir, etc., etc., C. H."

From all these gentlemen her labors and discoveries received the most cordial recognition. In his reply, Sir J. Banks said: "I shall take care to make our astronomical friends acquainted with the obligations they are under to your diligence." Mr. Aubert closes his letter with the assurance of the pleasure he felt at her success, and with the offer of any instrument she might wish to use; while Dr. Maskelyne addressed her as his "worthy sister in astronomy."

The fifth comet was discovered December 15, 1791, and all that she says about it is, "My brother wrote an account of it to Sir J. Banks, Dr. Maskelyne, and several other gentlemen." The sixth, found October 8th, is briefly recognized; and the seventh, discovered November 7, 1795, is known as Encke's comet, because he determined its periodicity. It was discovered by four different observers before its identity was recognized. Miss Herschel was its second discoverer in order of time. Her eighth and last comet was discovered August 6, 1797.

We learn from her diary that in October of this year her home with her brother at Slough was broken up, and she went to live in solitude in lodgings, and this mode of life she continued for twenty-five years, till her brother's death, when she left England to join her relations in Hanover. Why she left her brother's house she does not explain, nor is it necessary. In referring to her departure she only says: "My telescopes on the roof, to which I was to have occasional access, as also the room with the sweeping and observing apparatus, remained in their former order, where I most days spent some hours in preparing work to go on with at my lodgings." In a letter to Dr. Maskelyne, written in September, 1798, she says that, during the past year, she has not thought herself "well or in spirits enough to venture from home." She spent her first lonely winter in getting ready for the press some of her own astronomical work.

The account of her life from 1798 until her brother's death, in 1822, occupies about fifty pages of the volume, and consists mostly of extracts from her diary. It is not a record of discoveries or personal triumphs, but of unceasing labor for her brother, knowing no respite in sickness or in health, by night or by day, in winter or in summer, amid hardships and discouragements that never daunted her affectionate nature. During her first year in lodgings, she complains of being harassed by the loss of time in going backward and forward, and by not having immediate access to books and papers; and these troubles, with varying features, pursued her to the end of her brother's life. The first three or four years she changed her lodgings often, but in 1801 she settled in Upton, where she remained till 1810, at which time

she took possession of a cottage in Slough, belonging to her brother, and, although mention is made in her diary of moving again in 1814, yet she continued to live in Slough.

Notwithstanding all her prudence about paining relations, the multiplied repetition in her diary of such entries as the following is painfully suggestive:

"*March 5th.*—Went to make some stay with my brothers at Slough, Mrs. Herschel being in town.

"*27th.*—All returned, and I went with my work to Upton again.

"*September 24th.*—Went to work with my brother at Slough.

"*October 1st.*—Mrs. Herschel and niece returned. I went back to Upton.

"*August 1st.*—I left Upton for Slough. My brother went with Mrs. Herschel and Miss Baldwin on an excursion. I distracted my thoughts by undertaking an amazing deal of work.

"*September 8th.*—My brother and family returned, and I went with my works to Upton.

"*May 2d.*—I left Upton for Slough to work with my brother; Mrs. Herschel being in town till June 18th.

"*November 3d.*—I came home to Upton (Mrs. Herschel returned from Brighton), but went most days to assist my brother in the polishing-room or library, and, from the 10th of December to the 22d, was entirely at Slough, Mrs. Herschel being away.

"*January.*—I had a cough all the month; the communication between Slough and Upton very troublesome to me.

"*March 9th.*—Went to Slough to work with my brother; his family from home.

"*May 11th.*—Went to be with my brother; Mrs. Herschel went to town for a month.

"*June 12th.*—Mrs. Herschel returned from town, and I went home."

It is pleasant to find, however, that the asperities of this period of her life were so much softened by time and distance that in 1829, when living in Hanover, she was able to write to her sister-in-law, confidentially as to "a dear sister, for as such I now know you."

The diary closes in 1822, with an account of her brother's death, and her departure from England. We quote the following characteristic passage relating to this period. She had come as usual to spend the morning with her brother:

"*August 15th.*—I hastened to the spot where I was wont to find him, with the newspaper which I was to read to him. But instead I found Mrs. Morson, Miss Baldwin, and Mr. Bulman, from Leeds, the grandson of my brother's earliest acquaintance in this country. I was informed my brother had been obliged to return to his room, whither I flew immediately. Lady Herschel and the housekeeper were with him, administering everything which could be thought of for supporting him. I found him much irritated at not being able to grant Mr. Bulman's request for some token of remembrance for his father. As soon as he saw me, I was sent to the library to fetch one of his last papers, and a plate of the forty-foot telescope. But, for the universe, I could not have looked twice at what I had snatched from the shelf, and when he faintly asked if the

breaking up of the milky-way was in it, I said 'Yes,' and he looked content. I cannot help remembering this circumstance: it was the last time I was sent to the library on such an occasion."

Her brother William died on the 25th of August, and in the following October she settled in Hanover with her brother Dietrich.

When her brother died she was herself in feeble health, and expected soon to follow him to the grave, and it suited her feelings to go back to Hanover to die. Besides, she says:

"My whole life almost has passed away in the delusion that, next to my eldest brother, none but Dietrich was capable of giving me advice where to leave my few relics, consisting of a few books and my sweeper. And for the last twenty years I kept to the resolution of never opening my lips to my dear brother William about worldly or serious concerns, let me be ever so much at a loss for knowing right from wrong. And so it happened that, at a time when I was stupefied by grief at seeing the death of my dear brother, I gave myself with all I was worth (£500 of bank-stock) to my brother Dietrich and his family, and, from that time till the death of Dietrich, I found great difficulty to remain mistress of my own actions and opinions. In respect to the latter we never could agree."

Her brother William, however, left her a legacy of £100 a year, and during the rest of her life her chief study was how to spend this sum without making herself ridiculous.

As was to be expected, after fifty years' absence she found Hanover changed in everything, and little to her taste, and she was also grievously disappointed in the generation of relatives with whom she lived, and of whom she says:

"They have never been of the least use to me, and for all the good I have lavished on them they never came to look after me, but when they had some design upon me."

In speaking of her return to Hanover, her biographer writes thus:

"Who can think of her at the age of seventy-two, heart-broken and desolate, going back to the home of her youth to find consolation without a pang of pity? She little guessed how much her habits had changed in the different world where she had lived for fifty years. She had the bitterness to find herself alone with her great sorrow."

We have no space to give to this part of her life, although it occupies more than half of the volume, to which we must refer our readers. It is made up chiefly of her correspondence, and her letters, from their unconscious self-portraiture, are quite as interesting as her "Diary" or her "Recollections." It is full of interest also on account of the details it gives concerning the life of Sir William Herschel, of whom no reliable biography has yet appeared.

She died peacefully in 1848, and her funeral was held in the same garrison-church where she was christened and confirmed. According to a request made to her favorite niece, a lock of her brother's hair,

and an almost obliterated almanac, that had been used by her father, were placed with her in her coffin. The same niece, in a letter written at this time to her cousin, Sir John Herschel, says:

"I felt almost a sense of joyful relief at the death of my aunt, in the thought that now the unquiet heart was at rest. All that she had of love to give was concentrated on her beloved brother. . . . She looked upon progress in science as so much detraction from her brother's fame, and even your investigations would have become a source of estrangement had she been with you."

AWARDS AT THE INTERNATIONAL EXHIBITION.

REPORT OF HON. N. M. BECKWITH, COMMISSIONER FROM NEW YORK, ON THE SELECTION AND APPOINTMENT OF JUDGES.

AT a regular meeting of the Executive Committee of the United States Centennial Commission, held at Philadelphia, October 13, 1875, Mr. Beckwith, Commissioner from New York (United States Commissioner-General at the International Exhibition at Paris, 1867), presented the following report upon the selection and appointment of judges. It was carefully considered and unanimously approved:

HON. D. J. MORRELL, *Chairman of the Executive Committee.*

SIR: In compliance with the request of the Executive Committee, I beg leave to present for consideration the following suggestions relating to the selection and appointment of judges, in conformity with the method of awards decreed by the Centennial Commission.

This method, in many respects, differs radically from the systems hitherto tried in International Exhibitions, and, although the subject is familiar to you, I shall be pardoned, I hope, for briefly indicating the broad differences.

Awards have heretofore been generally made by an International Jury of about six hundred members.

The apportionment of jurors to countries has been tried on various bases, but was usually made on the basis of the relative space occupied by the products of each country respectively, in the Exhibition.

The Great Jury was divided into numerous small juries, who examined the products and prepared lists of the names of persons whom they proposed for awards, and the proposals thus made were confirmed or rejected by higher juries.

The awards consisted chiefly of medals of differents values, gold, silver, etc.

This system brought together a numerous and incongruous assembly, including unavoidably many individuals unqualified for the work.

The basis of representation was apparently fair, but its results were delusive.

A few countries nearest the Exhibition, whose products could be collected and exposed at the smallest proportional expense, occupied large spaces; the numerous remote countries filled smaller spaces.

The number of jurors allotted to the smaller spaces, when distributed, left

them without jurors on most classes, and in the remainder with only a minority which, in voting on awards, had no weight, and the awards were thus in effect decreed by the few contiguous countries whose products filled the largest spaces. Written reports on the products were not usually made by juries, and, if made, were not generally published; consequently no person outside of the jury was informed on what ground awards were made.

The medals, when distributed, were as silent as the verdicts; moral responsibility for the decisions attached to no one, and the awards thus made conveyed as little useful information, and carried as little weight, as anonymous work usually carries.

Medals, at best, are enigmas. They express nothing exactly and definitely relative to the products exhibited; their allegorical designs doubtless have a meaning in the mind of the artist who makes them, but allegorical designs are primitive and feeble language, and the medal of to-day is no more than its predecessor, a schoolboy token — verdicts upon products determined by majority votes of juries in which the producing countries are often represented by useless minorities—awards based upon anonymous reports, or reports never published, and final decisions announced and recorded in the vague and mystic language of medals, have not proved satisfactory to producers nor to the public. As regards the diffusion of reliable and useful information, International Exhibitions have not come fully up to expectations and to the promise implied in the great labor and great expenses which they involved; and the wide-spread dissatisfaction which has uniformly followed the close of jury-work affords in itself strong evidence that the system is not well adapted to the purposes of International Exhibitions.

The method of awards adopted by the Centennial Commission differs from preceding systems. It dispenses with the International Jury, and substitutes a body of two hundred judges, one-half foreign, chosen individually for their high qualifications.

It dispenses, also, with the system of awards by graduated medals, and requires of the judges written reports on the inherent and comparative merits of each product thought worthy of an award, setting forth the properties and qualities, presenting the considerations forming the ground of the award, and avouching each report by the signature of its author.

The professional judgment and moral responsibility of the judges being thus involved, assure the integrity of their reports. As awards to exhibitors, such reports will be more valuable than medals, in proportion to the greater amount of reliable information which they convey to the public. Their collected republication, as hand-books, will form valuable guides for all classes to the most advanced products of every country, and, *last and least*, the sales of them can hardly fail to return to the Commission a good portion of their cost.

The success of this method obviously depends on the judicious selection of the judges, and to this point I desire to call particular attention.

In this connection it may be remarked that the best judges of products are not usually found among their producers, but among their consumers.

To select a wine, for example, of particular character, one would not apply to wine-growers, but to dealers and consumers. On the merits of an engine, you would prefer the opinion of the engineer who uses it, to that of the engineer who invented or made it. The sugars and coffees of Brazil, Cuba, Java, etc., are best judged in the great markets of consumption. In brief, the food-products of the world find their most accurate appreciations, as regards their inherent qualities and comparative merits, in the great consuming markets,

where similar products from all regions are gathered, and the practical judgment of the using and consuming public is pronounced, from which there is no appeal.

The principle in this applies not only to raw products, but in a general sense to manufactures and to industrial products of all kinds in general use.

In this view of the subject, the method of awards adopted by the Centennial Commission presents the great advantage that it is *judicial* rather than *representative*, and the Commission is perfectly free to select judges from the best sources, regardless of localities.

The men to seek for are those who, by their ability, education, character, and experience, are fittest for the work, and they will be less difficult to find than to obtain, being generally employed, and frequently connected with large industries, important works, and the higher institutions to which their superior qualifications have led them.

Freedom to choose our judges from the best sources cannot fail to produce good results if the selection be made upon proper investigation, with suitable care and without favor.

The announcement of this method of awards has been received in foreign countries, as far as heard from, with expressions of distinct approbation, and there can be no doubt that they will select and bring to us their hundred judges, who will be distinguished by their reliable and solid qualifications, and it is incumbent on us to select a body of men of character, able and expert in their respective callings, and equal in attainments and experience to our foreign coöperatives, with whom our own will be intimately associated.

I need hardly add that the useful results and success of our Exhibition and the public satisfaction which it should produce, as well as the reputation of this Commission, as practical and sensible men, depend largely on the selection of our judges, and finally upon their organization and work. . . .

Respectfully submitted, N. M. BECKWITH.

NEW YORK, *October* 9, 1875.

RECENT ADVANCES IN TELEGRAPHY.

BY R. RIORDAN.

THE improvements in telegraphy, about which the public has lately been learning a good deal through the newspapers, really constitute a remarkable element of progress, and are deserving of separate consideration. With the fire-alarm, domestic, and district telegraphs in our cities, the reduced rates and increased efficiency of the great lines and the further improvements promised us, it does not seem too much to expect that the telegraph will soon rival the post-office and the press as a bearer and diffuser of intelligence.

The failure of the English postal telegraph to fulfill the sanguine prophecies of its advocates will hardly be held to militate against this view, when it shall be shown what the nature of these improvements is. Prof. Jevons, in a late number of the *Fortnightly Review*, has indicated the causes of this failure. It was taken for granted by the promoters of the scheme, he asserts, that, as in the case of the

Post-office, a vast increase of business might be done with but little more expense. Accordingly, to gain the increased business they reduced the rates one-half, and succeeded—but not in a pecuniary sense. Prof. Jevons ascribes this disappointing result to the great cost of erecting and maintaining the lines; to their small carrying capacity when compared with that of a railroad-train; and to the number of hands and *heads* which each telegraphic message has to pass through before reaching its destination, and which must all be paid. But the progress of the last five years, made principally in this country, has demonstrated that these difficulties are not insuperable.

In order of time, the first important step toward this end was the Duplex Telegraph of Mr. Joseph Stearns, of Boston, Massachusetts. Its object is to allow of two operators using the same wire to send messages in opposite directions simultaneously. To persons having only a general acquaintance with the ordinary working of the telegraph, this at first seemed impossible; and, when it was accomplished, it was held by many—some scientific men among the number—to furnish an indubitable proof of the theory that the electric waves, or currents, or whatever they might be held to be, necessarily passed each other in contrary directions over the wire. That they do not will be evident from the subjoined explanation.

It must be remembered that the galvanic battery gives birth to a force which returns in a circuit to where it was generated, and accelerates the liberation of more force, being like a steam-engine employed partly in fanning its own fire. This circuit can be performed much more easily through great lengths of some substances, such as the earth and metals, than through very small spaces of others, as the air and the dilute acid of the battery. Galvanic electricity is, therefore, strictly confined in a sort of mill-round; or it may best, for our present purposes, be represented by water flowing through such a system of water-courses as is shown in the annexed cut. We will

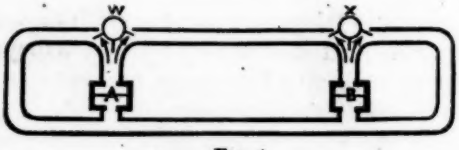


FIG. 1.

suppose them to include a reservoir and a secondary circuit at each end. Let the reservoirs *A* and *B* have water pumped into them by force-pumps, and distributed by them to both the main and secondary circuits, in equal quantities and in the direction of the arrows, so as to maintain the water-wheels *X* and *W* in the same positions. The highest points in the system must be supposed to be at the front of the reservoirs, and the lowest at the back of them.

If an additional volume of water come from *A*, being equally divided

on each side of *W*, it will not move that wheel, but it will move the wheel *X* by destroying the balance which previously existed there. But, if a similar extra volume be at the same time sent from *B*, the pressure in that part of the circuit between *W* and *X* will overcome the opposing forces at each of the points, and both wheels will be worked, each virtually by the distant reservoir and not by its own.

If we substitute galvanic batteries for the reservoirs, wires for the water-courses, and electricity for the water, this gives us the principle of the duplex telegraph, and it is obvious that no currents passing one another in contrary directions are necessary to it. It will be well to keep this in mind when we come to describe the quadruplex system.

Following the duplex, the American Automatic system may be said to have been perfected in 1873. The great rapidity with which messages are transmitted and recorded by it is its principal advantage, but it has others—as requiring a smaller force of operators and less specially skilled. The usual work of a Morse operator is acknowledged to be about 1,500 words an hour, and European operators do not average half as much; but, by the automatic method, to receive and print *double* that number of words per *minute* is an ordinary feat, and as many as 7,000 words—fourteen pages of this magazine—have been legibly recorded in that time. As every word contains, on an average, five letters, and as each letter is represented by a varying

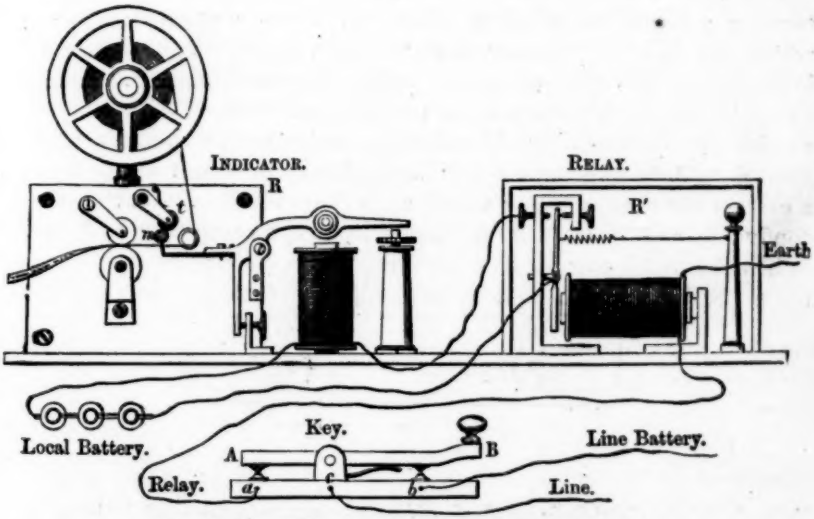


FIG. 2.—MORSE KEY AND REGISTER. (From Deschanel.)

number of dots and dashes, each formed by a separate discharge, the circuit, it is calculated, must be "closed" and "broken," and the chemicals in the battery must cease and recommence their action 60,000 times per minute, in the ordinary working of the automatic system.

In every form of electric telegraph the signals are given by an intermittent flow of electricity. In the Morse system a "key" is used which, in its normal position, "breaks" the circuit, but when depressed by the finger of the operator allows the electricity to pass through it on its mission. Arrived at the distant station, it is converted, by means of an electro-magnet, into mechanical motion, which is utilized either to produce indentations in a moving slip of paper by means of a style, or, more commonly, to give a series of taps, which the operator understands, by an instrument called a "sounder."

In the automatic system the means employed are altogether different. The message is, first of all, prepared by punching holes in a narrow ribbon of paper. These perforations are so grouped as to represent the dots and dashes of the telegraphic alphabet, and by the punching-machine, which is very complicated, all that are required to form a letter are punched at one stroke. In comparing the two systems this must not be lost sight of, as the time taken in punching must, of course, be added to the time of transmission. The machine, however, does its work more quickly than the Morse operator with his key, and, the time occupied in transmitting being so vastly less, the "automatic" may claim to have rendered old-fashioned telegraphy comparatively slow.

After the perforated slip of paper has been prepared, it is taken to the operator's table, where it is made to move forward rapidly between a metallic drum and a needle carrying two small steel wheels which rest upon it. Drum and wheels form part of the circuit, which is broken by the non-conducting paper interposed and closed when the holes permit of the wheels and the metallic cylinder beneath coming into contact. At the receiving-station a very similar arrangement does duty as a register. The paper slip is there saturated with a certain chemical solution which renders its whole substance a good conductor, and, instead of the wheels, there is an iron style or "pen." When electricity arrives over the line, it decomposes the moisture of the paper into oxygen and hydrogen, and oxidizes or rusts the pen.

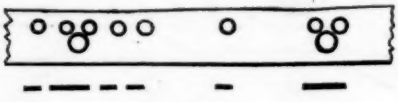


FIG. 3.

A little of this oxide is rubbed off by the quickly-moving paper, and enters into combination with the chemical still contained in it, producing a stain in the form of a dot or dash which corresponds with the holes punched in the paper at the sending-station. Where three holes come together, both wheels form a contact, and a dash is produced, because the second wheel touches the cylinder while the first passes over the paper between the upper holes.

The germ of the automatic system, as we have described it, was contained in the "Chemical Telegraph" invented by Alexander Bain, a Scotchman, in 1846. Bain was the first to use the perforated paper to transmit and the chemically-prepared paper to receive the message. But his invention, from a practical point of view, bears about the same relation to the American system which the steam-engine as known to the ancients does to that of James Watt. Bain's system, improved by the late Sir Charles Wheatstone and known as Wheatstone's automatic system, is employed to a limited extent in Great Britain; but, thus improved, its speed does not exceed 60 to 100 words a minute. It is therefore proper to regard the American Automatic Telegraph as a distinct American invention. In its present form, we owe it to Mr. Thomas A. Edison, of Newark, New Jersey.

The accompanying cut (Fig. 4) illustrates the results of attempting

Fig. 4.

high speed on the Bain telegraph. Instead of recording themselves by decided dots and dashes, the electric discharges leave indistinct and elongated traces, which, when the speed amounts to 300 words or over, run into one another and make a continuous line. This effect is due to the property which all electrified bodies have of inducing electricity in neighboring bodies. The earth, reacting on the line wire suspended above it, induces in it what is called an extra current, both on closing and breaking the circuit. On first closing the circuit the extra current runs in the contrary direction to the primary, and retards and weakens its action, so that, if suffered to record itself, it would do so by a mark like this: the long after-part being caused partly by the accumulated electricity and partly by the second extra current which is in the same direction with the primary one.

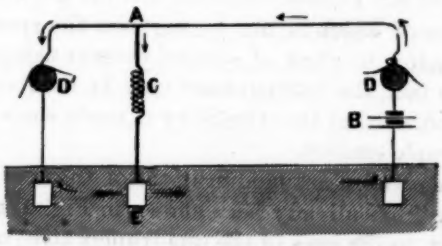


Fig. 5.

By Mr. Edison's plan the evil is made to cure itself. He simply interposes another wire with a coil, shown at *A C E*, (Fig. 5). This divides the current, one part of which is again subdivided on

reaching the earth, and a moiety of it ascending the ground-line at *D'* counteracts the first weak installment of the other. Then, as each turn of the coil, *C*, acts the part of the earth on the turn next it, the whole sets up another powerful extra current, which at first forces the full strength of the main current through the recording instrument, and ultimately counteracts the accumulated electricity and the second extra current due to the earth. In practice, several such lines are used, and magnets, which are preferable, instead of coils. This occasions a great loss of electricity, but the sensitiveness of the receiving apparatus is such that less than one-fourth of the total strength of the current is sufficient to give a good record.

The chemical used by Bain in his sensitized paper was ferrocyanide of potassium, which, with the oxide from the iron pen and an extra equivalent of oxygen, forms Prussian blue. The oxygen of the air, it has been found, protracts this action, and thus arises another source of confusion, which is not affected by the device just described. A preferable combination, requiring only the protoxide of iron, which is formed immediately by the electricity, is used in the American system.

One of the most curious of the recent discoveries respecting the chemical action of electricity is that of its usefulness, under certain circumstances, as a lubricator. During Mr. Edison's experiments on the automatic telegraph he perceived that, when using a paper soaked in a certain solution, the pen was apt to slip whenever a discharge occurred. This effect was found to be so marked that a person drawing a strip of metal along the paper—leaning rather heavily on it—finds his hand obliged to move in a succession of jerks when signals are sent by a current powerful enough to overcome the resistance of his body. On this principle, Mr. Edison has constructed a little instrument in which a style is kept pressed against the paper by springs so as to make a continuous indentation, except when the current is passing. Its record is, therefore, the reverse of that of a Morse register; but the "electromotograph," as it is called, differs also from the "Morse" in being the most sensitive recording instrument known.

Still another of Mr. Edison's inventions is the quadruplex telegraph, the principal aim of which is, not to augment the speed of signaling, but, like the duplex, to allow of several persons using the same wire at one time. In fact, the arrangement may be used as a duplex telegraph, if required, so that the wire is by it made susceptible of either double or quadruple employ.

The instruments used are modifications of those of the Morse system. The "key" has already been shown in Fig. 2, and the changes made to adapt it to the uses of the quadruplex telegraph may be understood from Fig. 5. The essential part of the receiving instrument is an electro-magnet, which is shown in Fig. 2, and consists of a bent bar of soft iron, surrounded at each end by a coil of wire connected with the wire of the line. The current, passing through these coils,

communicates to the iron core magnetic properties, and enables it to attract another piece of iron or steel called its armature; but, when the current ceases, the magnetism ceases also, and a spring—too weak to neutralize it—draws back the armature. It is shown in section at *M*, in Fig. 6. When the armature and the lever carrying it are discarded, and instead of them a jointed tongue of steel, as at *P M*, is inserted between the poles of the magnet, it will be unaffected by the current except when a change occurs in its direction. It is then called a polarized magnet. Its use will be explained a little further on. One

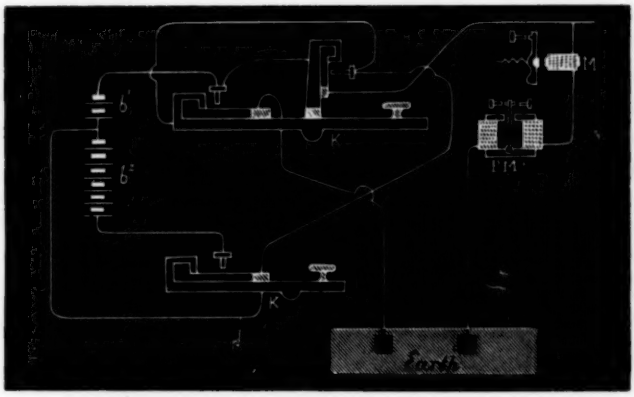


FIG. 6.

of the keys, *K*, in the diagram, is provided with a spring, which is in contact with the metal of the key when this latter is in its normal position, and maintains across the key a circuit including a portion of the battery *b'*. But when the key is depressed the spring comes in contact with a screw, to which another circuit is connected, applying the full strength of the battery to the line. The circuit across the key is never broken, because the spring remains in contact with the arm of the key until it begins to press against the screw. This key works the magnet *M*, which has its retractile spring so adjusted as to be overcome only by the full intensity of the current when the key is down. The other key, *K'*, is for changing the direction of the current, and working the polarized magnet, *P M*. Its construction is such that, when not in use, one pole of the battery, the positive, for example, is in connection with the line, and the negative with the earth, necessitating the passage of the current through the line in the first place; but when the key is touched the negative pole is connected "to line" and the positive to earth, reversing the direction of the current. These reversals of direction operate, as has been said, the polarized magnet *P M*.

To revert to the illustration we made use of in describing the duplex, let the reader picture to himself a water-course in which both

the direction and the volume of the current can be changed at pleasure. He can suppose, in addition to the water-wheels before figured, and which will indicate the force of the stream, a pair of hinged valves or gates, which, whether the current be strong or weak, will be moved only by a change in its direction. The former will represent the ordinary magnets, and the latter the polarized magnets.

It is plain that, so far, this is only another form of duplex, sending two messages in the same direction at once. To make it a quadruplex telegraph it is necessary, in the first place, to add to it Stearns's duplex, or a contrivance similar to it. Even then a dead-lock would happen when the currents sent from each end of the line should be of the same intensity, and opposite in direction; that is, when all eight operators were working together. To remedy this, extra batteries are introduced, which are neutralized by part of the current in the main circuit, when that is in a working condition, but are set free to work the instruments when the currents in the main circuit destroy one another. In the diagram the extra batteries, etc., have been omitted, as also the transmitting apparatus of one station and the recording instruments of the other.

Although not strictly coming under its title, because belonging, as yet, rather to the future, this article would hardly be complete without some reference to a scheme of multiplex telegraphy which promises results of the greatest importance. The ingenious magnetic apparatus used by Prof. Helmholtz, of Berlin, in his researches in acoustics, was too suggestive not to have inspired more than one inventor with the idea of turning it to account in telegraphy. Accordingly, several, both here and in Europe, have been trying to realize it, and it is likely that the magnetically-excited tuning-forks, or the sonorous steel bars which may be substituted for them, will shortly be heard in every telegraph-office. There seems, so far, to be no ascertained limit to the number of distinct musical notes which may be propagated on a single wire at one time; and, when that limit is found, it is likely that it may be doubled or quadrupled by means of the former systems. The reduction in the cost of erection and maintenance of wires which this will bring about will be an enormous saving to telegraph companies, especially to any new ones that may be formed, or to the Government, if it should undertake the control and extension of the service.

An interesting experiment of Sir Charles Wheatstone's on the transmission of sound through solid linear conductors has, perhaps, helped to suggest this approaching transformation of the telegraph. An account of it was published in 1831. A narrow wooden rod was attached at one end to the sounding-board of a piano, and, after passing through two empty rooms, was joined at the other end to a sounding-board alone. Any piece of music played on the piano was distinctly heard by means of the sounding-board in the distant room. And not the

least confusion ensued from the crowding together, for a considerable distance, of the multitude of intricately-related vibrations in a rod having a section of but one square inch.

Prof. Helmholtz's apparatus consisted of a number of electro-magnets acting on tuning-forks pitched to particular notes. His object was so to combine those notes as to demonstrate the formation of certain harmonious sounds; but the object of the telegraph-inventors is the reverse of that, namely, to transmit them in the form of *electric* vibrations to a distance, and then—as in Wheatstone's experiment—to sift them out again to separate instruments. In most of the plans so far made public, a fixed steel bar takes the place of the tuning-fork, and therefore of the armature as well. When attracted by the magnet, on making a signal, it is of course set vibrating; and, at every forward vibratory movement, it closes the circuit and transmits an electric impulse. A number of such magnets, their sonorous armatures sending each a different number of pulsations in a second, may be working away at once, and the corresponding instruments at the other end of the line will be acted on only by those which suit their times of vibration. In other words, of the total number of electric charges sent into the line, only those will act on any particular magnet at the receiving end which suffice to cause in its armature the number of vibrations per second to which it was set. This, of course, is the same number which was sent by the transmitting instrument of the same pair. Practically, the different tones are not reproduced quite unmixed, every armature being capable of responding though in a less degree, to other notes than its own; so that the effect on the ear, at one of the receiving magnets, is like that of a number of persons talking together in different keys: some quite loudly; some in a lower tone; others in a whisper. To remedy this, different forms of resonators are being tried, adapted to swell the special sounds that should be heard.

The "electromotograph," described in connection with chemical telegraphs, is intended, by its inventor, to be used with some form of this acoustic system. Mr. Gray, of Chicago, another well-known telegraph-inventor, is also understood to have made considerable progress in this direction.

It is matter of reasonable pride to find, at the commencement of our second century, the names of Americans so prominently connected with all the great improvements in the art which owes so much to the labors of Morse and Henry.

CONSCIENCE IN ANIMALS.

By G. J. ROMANES, M. A., F. L. S.

AMONG several other topics which are dealt with in an interesting article entitled "Animal Depravity" that appeared in the *Quarterly Journal of Science* for October last, the writer alludes to the question as to whether or not the rudiments of a moral sense are discernible in animals. This question I consider to be of so much importance from a psychological point of view that, although a great deal of observation which I have directed toward its enlightenment has hitherto yielded but small results, I am tempted to publish the latter, such as they are, in the hope that, if they serve no better end, they may perhaps induce some other observers to bestow their attention upon this very interesting subject.

I may first briefly state what I conceive to be the theoretical standing of the subject. At the present day, when the general theory of evolution is accepted by all save the ignorant or the prejudiced, the antecedent probability is overwhelming that our moral sense, like all our other psychological faculties, has been evolved. The question as to the *causes* of its evolution has been discussed in the "Descent of Man," and this with all the breadth of thought and force of fact so characteristic of the writings which have exerted an influence upon human thought more profound than has been exerted by the writings of any other single man—not even excepting Aristotle in philosophy or Newton in science. Mr. Herbert Spencer, also, has treated of this subject, and, if his wonderful "programme" is ever destined to attain completion, we may expect copious results when his great powers are brought to bear upon the "Principles of Morality." Meanwhile, however, we have ample evidence to render it highly probable that at any rate the leading causes in the development of our moral sense have had their origin in the social instincts. Indeed, to any one who impartially considers this evidence in the light of the general theory of evolution, it must appear wellnigh incredible that so considerable a body of proof can ever admit of being overcome. Nor is this all. Not only is it true that so much success has attended Mr. Darwin's method of determining synthetically the causes which have been instrumental in evolving the moral sense,[1] but, long before any scientific theory of evolution had been given to the world, our great logician—following in the track of Hume (whose part in this matter has not, I think, been sufficiently appreciated), Bentham, and others—proved

[1] I willingly indorse the just tribute recently paid to this part of Mr. Darwin's work by Prof. Clifford: "To my mind the simplest and clearest and most profound philosophy that was ever written upon this subject is to be found in chapters ii. and iii. of Mr. Darwin's 'Descent of Man.'"—*Fortnightly Review*, p. 794.

analytically, to the satisfaction of all competent and impartial thinkers, that the moral sense is rooted in "the greatest amount of happiness principle" as its sustaining source. In other words, John Stuart Mill, by examining conscience as he found it to exist in man, showed that it depends upon the very principle upon which it ought to depend, supposing Mr. Darwin's theory—elaborated, be it remembered, without any reference to Mr. Mill's analysis, and arrived at by a totally different line of inquiry—concerning the causes of its evolution to be the true one.

Stronger evidence, then, as to the physical causes whose operation has brought human conscience into being, we could scarcely expect, in the present condition of physical science, to possess. It is unnecessary, however, in this place to enter into the details of this evidence, as almost every educated person must be more or less acquainted with them. I shall therefore pass on to the next point which concerns us—namely, supposing the causes of our moral sense to have had their origin in the social instincts, where and to what extent should we expect to find indications of an incipient moral sense in animals? First, then, what do we mean by conscience? We mean that faculty of our minds which renders possible remorse or satisfaction for past conduct, which has been respectively injurious or beneficial to others.[1] This, at least, is what I conceive conscience to be in its last resort. No doubt, as we find it in actual operation, the faculty in question has reference to ideas of a higher abstraction than that of the fellow-man whom we have injured or benefited. In most cases the moral sense has reference to the volitions of a Deity, and in others to the human race considered as a whole. But, if the moral sense has been developed in the way here supposed, its root-principle must be that which has reference to ideas of no higher abstraction than those of parent, neighbor, or tribe. Now, even in this its most rudimentary phase of development, conscience presupposes a comparatively high order of intelligence as the prime condition of its possibility. For not only does the faculty as above defined require a good *memory* as a condition essential to its existence, but—what is of much greater importance—it also requires the power of *reflecting upon past conduct;* and this, it is needless to say, appears to be a much rarer quality in the psychology of animals than is mere memory.

Thus, if Mr. Darwin's theory concerning the origin and development of the moral sense is true, we should not expect to find any indications of this faculty in any animals that are too low in the psychological scale to be capable of reflecting upon their past conduct. Whether this limitation does not exclude all animals whatever is a question with which I am not here concerned. I merely assert that, if the theory in question is the true one, and if no animals are capable

[1] For reasons which may easily be gathered from the next succeeding sentences, I omit *conscientious* ideas of what is due to *self*.

of reflecting upon their past conduct, then no animals can possess a moral sense, properly so called. And from this, of course, it follows that, if any animals can be shown to possess a moral sense, they are thereby also shown to be capable of reflecting upon their past conduct.

Again, if Mr. Darwin's theory concerning the origin and development of the moral sense is true, it is self-evident that we should not expect to find any indications of this faculty in animals that are either unsocial or unsympathetic. Supposing the theory true, therefore, our search for animals in which we may expect to find any indications of a moral sense is thus seen to be very restricted in its range: we can only expect to find such indications in animals that are highly intelligent, social, and sympathetic. Since, by the hypothesis, conscience requires a comparatively rare collocation of conditions for its development, we must expect to find it a comparatively rare product.

Lastly, as it is quite certain that no animal is capable of reflecting upon past conduct in any high degree, and as we have just seen that the moral sense depends upon the faculty of so reflecting, it follows that we cannot expect to find any animal in which the moral sense attains any high degree of development.

We are now in a position to draw some important distinctions. There are several instincts and feelings which, when expressed in outward action, more or less simulate conscience (so to speak), but which it would be erroneous to call by that name. For instance, the maternal instinct, although it leads in many cases to severe and sustained self-denial for the benefit of the offspring, is nevertheless clearly distinct from conscience. The mother in tending her young does so in obedience to an inherited instinct, and not from any fear of subsequent self-reproach if she leaves her family to perish. She follows the maternal instinct, so long as it continues in operation, just as she would follow any other instinct; and it is, as it were, a mere accident of the case that in this particular instance the course of action which the instinct prompts is a course of action which is conducive to the welfare of others. An illustration will render this distinction more clear. In his chapter on the "Moral Sense," Mr. Darwin alludes to the conflict of instincts which sometimes occurs in swallows when the migratory season overtakes a late brood of young birds; at such times "swallows, house-martins, and swifts, frequently desert their tender young, leaving them to perish miserably in their nests." And further on he remarks: "When arrived at the end of their long journey, and the migratory instinct has ceased to act, what an agony of remorse the bird would feel if, from being endowed with great mental activity, she could not prevent the image constantly passing through her mind of her young ones perishing in the bleak north from cold and hunger!" In other words, if we could suppose the mother-bird under such circumstances to be capable of *reflecting upon her past conduct*, and, as

a consequence, suffering an "agony of remorse," then the bird might properly be said to be *conscience-stricken*. And if we could suppose the bird, while still brooding over her young ones, to foresee the agony of remorse she would subsequently feel if she now yields to the stronger instinct by deserting her young, then the bird might properly be said to be acting *conscientiously*.

Again, mere fear of punishment must not be confused with conscience—it being of the essence of conscientious action that it should be prompted by feelings wholly distinct from fear of retaliation by the object of injury, whether by way of punishment or revenge. Conscience must be capable of effecting its own punishment if violated; otherwise the principle of action, whatever it may be, must be called by some other name.[1]

It is evident that conscience, as we find it in ourselves, is distinct from love of approbation and fear of disapprobation. Nevertheless, if our hypothesis concerning the development of the moral sense is the true one, we should expect that during the early phases of that development love of approbation and fear of disapprobation should have played a large part in the formation of conscience. For although, by the hypothesis, it is sympathy and not self-love that constitutes the seat of the moral sense, still the particular manifestations of self-love with which we are now concerned—viz., desire of approbation and dislike of the reverse—would clearly be impossible but for the presence of sympathy. "Mr. Bain has clearly shown that the love of praise, and the strong feeling of glory, and the still stronger horror of scorn and infamy, 'are due to the workings of sympathy.'"[2] I think, therefore, that in testing—by observations upon the lower animals—the truth of Mr. Darwin's theory concerning the genesis of conscience, it would be no valid objection to any satisfactory instances of conscientious action in an animal to say that such action is partly due to a desire of praise or a fear of blame. This would be no valid objection, because, in the first place, it would in most cases be impossible to say how far the implication is true—how far the animal may have acted from pure sympathy or regard for the feelings of others, and how far from an admixture of sympathy with self-love; and in the next place, even if the implication be conceded wholly true, it would not tend to disprove the theory in question. If an animal's sympathies are so powerful that, even after being reflected through self-love, they still retain force enough to prompt a course of action which is in direct opposition to the more immediate dictates of self-love, then the sympathies of such an animal are hereby proved to be sufficiently exalted to

[1] Of course I recognize fear of punishment as an important factor in the *original constitution* of the moral sentiment; but, for reasons stated at the end of this article, we must, when treating of animal psychology, eliminate this factor when *conscience has become sufficiently developed to be "a law to itself."*

[2] "Descent of Man," p. 109 (1874). "Mental and Moral Science," p. 254 (1868).

constitute the beginnings of a conscience, supposing the theory which we are testing to be the true one.

Similarly, there is an obvious distinction in ourselves between injured conscience and injured pride. But, if conscience has been developed in the way here supposed, it follows that in the rudimentary stages of such development the distinction in question cannot be so well defined. Pride presupposes consideration for the opinion of others, and this in turn—as we have just seen—presupposes sympathy, which is the foundation-stone of conscience. Now, it is certain that long before we reach, in the ascending scale of animal psychology, intellectual faculties sufficiently exalted to admit even of our suspecting the presence of an incipient moral sense, we can perceive abundant indications of the presence of pride. And, forasmuch as animals that are high in the psychological scale frequently exhibit a very profound appreciation of their own dignity, we may pretty safely conclude that in no case can we expect to find indications of a moral sense in an animal without a greater or less admixture of pride.

I will now sum up this rather tedious preamble: From Mr. Darwin's theory concerning the development of conscience, it appears to follow that the presence of this faculty in animals must be restricted—if it occurs at all—to those which are intelligent enough to be capable in some degree of reflecting upon past conduct, and which likewise possess social and sympathetic instincts. From the first of these conditions it follows, supposing Mr. Darwin's theory true, that in the case of no animal should we expect to find the moral sense developed in any other than a low degree.

There is no reason to suppose any mere *instinct* (such as the maternal) due to conscience; for an instinct acquired by inheritance is obeyed blindly, in order to avoid the uncomfortable sensation which ensues in a direct manner if it is not so obeyed; whereas conscience enforces obedience only through a process of reflection;[1] the uncomfortable sensation which non-obedience entails in this case being only brought about in an indirect manner through the agency of representative thought.

Although conscience in man is independent of, or distinct from, love of approbation, fear of reproach, and sense of pride, there is no reason why we should suppose conscience in its rudimentary forms to be independent of these passions. On the contrary, I think we should expect a rudimentary form of conscience to be more or less amalgamated with such passions; for, long before the faculty in question has attained the highly-differentiated state in which we find it to be present in ourselves, it must (by the hypothesis) have passed through in-

[1] i. e., *originally:* when once the *habit* of yielding obedience to conscience has been acquired, it becomes itself of the nature of an instinct—neglect to practise this habit giving rise immediately, or without any process of reflection, to an uncomfortable state of the mind.

numerable states of lesser differentiation in which its existence was presumably more and more bound up with that of those more primary social instincts from which it first derived its origin. To us conscience means a massive consolidation of innumerable experiences, inherited and acquired, of remorse following one class of actions and gratification their opposites; and this massive body of experience has reference to ideas of an abstraction so high as to extend far beyond the individual, or even the community, which our actions primarily affect. No wonder, therefore, that, when any course of action is being contemplated, conscience asserts her voice within us as a voice of supreme authority, commanding us to look beyond all immediate issues, inclinations, and even sympathies, to those great *principles* of action which the united experience of mankind has proved to be best for the individual to follow in all his attempts to promote the happiness or to alleviate the misery of his race. But with animals, of course, the case is different. They start with a very small allowance of hereditary experience in the respects we are considering; they have very few opportunities of adding to those experiences themselves; they probably have no powers of forming abstract ideas; and so their moral sense, rudimentary in its nature, can never be exercised with reference to anything other than concrete objects—relation, companion, or herd.

We may now proceed to answer the question already propounded, namely: Supposing Mr. Darwin's theory concerning the origin of the moral sense to be true, where among animals should we expect to find indications of such a sense? I think reflection will show that the three essential conditions to the presence of a moral sense are only complied with among animals in the case of three groups—namely, dogs, elephants, and monkeys. I need not say anything about the *intelligence* or the *sociability* of these animals, for it is proverbial that there are no animals so intelligent or more social. It is necessary, however, to say a few words about sympathy.

In the case of dogs sympathy exists in an extraordinary degree. I have myself seen the life of a terrier saved by another dog which staid in the same house with him, and with which he had always lived in a state of bitter enmity. Yet, when the terrier was one day attacked by a large dog, which shook him by the back, and would certainly have killed him, his habitual enemy rushed to the rescue, and, after saving the terrier, had great difficulty in getting away himself.

With regard to elephants, I may quote the well-known instance from the "Descent of Man:" "Dr. Hooker informs me that an elephant, which he was riding in India, became so deeply bogged that he remained stuck fast until next day, when he was extracted by means of ropes. Under such circumstances elephants seize with their trunks any object, dead or alive, to place under their knees, to prevent their sinking deeper in the mud; and the driver was dreadfully

afraid lest the animal should have seized Dr. Hooker and crushed him to death. But the driver himself, as Dr. Hooker was assured, ran no risk. This forbearance, under an emergency so dreadful for a heavy animal, is a wonderful proof of noble fidelity."[1]

Many cases of sympathy in monkeys might be given, but I shall confine myself to stating one which I myself witnessed at the Zoölogical Gardens.[2] A year or two ago, there was an Arabian baboon and an Anubis baboon confined in one cage, adjoining that which contained a dog-headed baboon. The Anubis baboon passed its hand through the wires of the partition, in order to purloin a nut which the large dog-headed baboon had left within reach—expressly, I believe, that it might act as a bait. The Anubis baboon very well knew the danger he ran, for he waited until his bulky neighbor had turned his back upon the nut with the appearance of having forgotten all about it. The dog-headed baboon, however, was all the time slyly looking round with the corner of his eye, and no sooner was the arm of his victim well within his cage than he sprang with astonishing rapidity and caught the retreating hand in his mouth. The cries of the Anubis baboon quickly brought the keeper to the rescue, when, by dint of a good deal of physical persuasion, the dog-headed baboon was induced to let go his hold. The Anubis baboon then retired to the middle of his cage, moaning piteously, and holding the injured hand against his chest while he rubbed it with the other one. The Arabian baboon now approached him from the top part of the cage, and, while making a soothing sound, very expressive of sympathy, folded the sufferer in its arms—exactly as a mother would her child under similar circumstances. It must be stated, also, that this expression of sympathy had a decidedly quieting effect upon the sufferer, his moans becoming less piteous so soon as he was enfolded in the arms of his comforter; and the manner in which he laid his cheek upon the bosom of his friend was as expressive as anything could be of sympathy appreciated. This really affecting spectacle lasted a considerable time, and while watching it I felt that, even had it stood alone, it would in itself have been sufficient to prove the essential identity of some of the noblest among human emotions with those of the lower animals.

If there is any validity in the foregoing antecedent reflections, all who have the opportunity should make a point of observing whether any indications of conscience are perceptible in monkeys, elephants, or intelligent dogs. My own opportunities of observation have been restricted to the last of these animals alone, so I shall conclude this article by giving some instances which appear to me very satisfactorily to prove that intelligent and sympathetic dogs possess the rudiments of a moral sense.

[1] *See*, also, Hooker's "Himalayan Journal," vol. ii., p. 333 (1854).

[2] I hope it is unnecessary to say that, in detailing this and all the subsequent incidents, I carefully avoid exaggeration or embellishment of any kind.

I have a setter just now which has been made a pet of since a puppy. As he has a very fine nose, and is at liberty to go wherever he pleases, he often finds bits of food which he very well knows he has no right to take. If the food he finds happens to be of a dainty description, his conscientious scruples are overcome by the temptations of appetite; but, if the food should be of a less palatable kind, he generally carries it to me in order to obtain my permission to eat it. Now, as no one ever beats or even scolds this dog for stealing, his only object in thus asking permission to eat what he finds must be that of quieting his conscience. It should be added that when he brings stolen property to me it does not always follow that he is allowed to keep it.

This same animal, when I am out shooting with him, sometimes of course flushes birds. When he does so he immediately comes to me in a straight line, carrying his head and tail very low, as if to ask for pardon. Although I speak reproachfully to him on such occasions, I scarcely ever chastise him; so it cannot be fear that prompts this demeanor.

One other curious fact may here be mentioned about this dog. Although naturally a very vivacious animal, and, when out for a walk with myself or any other young person, perpetually ranging about in search of game, yet if taken out for a walk by an elderly person he keeps close to heel all the time—pacing along with a slow step and sedate manner, as different as possible from that which is natural to him. This curious behavior is quite spontaneous on his part, and appears to rise from his sense of the respect that is due to age.

The writer of the article on "Animal Depravity" makes the following quotation from an article of mine in *Nature* (vol. xii., page 66): "The terrier used to be very fond of catching flies upon the window-panes, and if ridiculed when unsuccessful was evidently much annoyed. On one occasion, in order to see what he would do, I purposely laughed immoderately every time he failed. It so happened that he did so several times in succession—partly, I believe, in consequence of my laughing—and eventually he became so distressed that he positively *pretended* to catch the fly, going through all the appropriate actions with his lips and tongue, and afterward rubbing the ground with his neck as if to kill the victim; he then looked up at me with a triumphant air of success. So well was the whole process simulated that I should have been quite deceived, had I not seen that the fly was still upon the window. Accordingly, I drew his attention to this fact, as well as to the absence of anything upon the floor; and, when he saw that his hypocrisy had been detected, he slunk away under some furniture, evidently very much ashamed of himself."

Upon this case the author of the article on "Animal Depravity" very properly observes: "This last point is most significant, fully overturning the vulgar notion of the absence of moral life in brutes,

and of their total want of conscience." I think this observation is warranted by the facts, for although I have heard it objected that the feeling displayed by the terrier in this case was that of wounded pride rather than of wounded conscience, still, from what has been previously said concerning this distinction in the case of animals, it will be seen that in this instance it is not easy to draw the line between these two sentiments.

The following instances, however, all of which occurred with the terrier just mentioned, are free from this difficulty:

For a long time this terrier was the only canine pet I had. One day, however, I brought home a large dog, and chained him up outside. The jealousy of the terrier toward the new-comer was extreme. Indeed, I never before knew that jealousy in an animal could arrive at such a pitch; but, as it would occupy too much space to enter into details, it will be enough to say that I really think nothing that could have befallen this terrier would have pleased him so much as would any happy accident by which he might get well rid of his rival. Well, a few nights after the new dog had arrived, the terrier was, as usual, sleeping in my bedroom. About one o'clock in the morning he began to bark and scream very loudly, and, upon my waking up and telling him to be quiet, he ran between the bed and the window in a most excited manner, jumping on and off the toilet-table after each journey, as much as to say: "Get up quickly; you have no idea of what shocking things are going on outside!" Accordingly, I got up, and was surprised to see the large dog careering down the road; he had broken loose, and, being wild with fear at finding himself alone in a strange place, was running he knew not whither. Of course I went out as soon as possible, and after about half an hour's work succeeded in capturing the runaway. I then brought him into the house and chained him up in the hall; after which I fed and caressed him with the view of restoring his peace of mind. During all this time the terrier had remained in my bedroom, and, although he heard the feeding and caressing process going on down-stairs, this was the only time I ever knew him fail to attack the large dog when it was taken into the house. Upon my reëntering the bedroom, and before I said anything, the terrier met me with certain indescribable grinnings and prancings, which he always used to perform when conscious of having been a particularly good dog. Now, I consider the whole of this episode a very remarkable instance in an animal of action prompted by a sense of *duty*. No other motive than the voice of conscience can here be assigned for what the terrier did; even his strong jealousy of the large dog gave way before the yet stronger dread he had of the remorse he knew he should have to suffer, if next day he saw me distressed at a loss which it had been in his power to prevent. What makes the case more striking is, that this was the only occasion during the many years he slept in my bedroom that the terrier disturbed

me in the night-time. Indeed, the scrupulous care with which he avoided making the least noise while I was asleep, or pretending to be asleep, was quite touching, even the sight of a cat outside, which at any other time rendered him frantic, only causing him to tremble violently with suppressed emotion when he had reason to suppose that I was not awake. If I overslept myself, however, he used to jump upon the bed and push my shoulder gently with his paw.

The following instance is likewise very instructive: I must premise that the terrier in question far surpassed any animal or human being I ever knew in the keen sensitiveness of his feelings, and that he was never beaten in his life.[1] Well, one day he was shut up in a room by himself, while everybody, in the house where he was, went out. Seeing his friends from the window as they departed, the terrier appears to have been overcome by a paroxysm of rage; for when I returned I found that he had torn all the bottoms of the window-curtains to shreds. When I first opened the door he jumped about as dogs in general do under similar circumstances, having apparently forgotten, in his joy at seeing me, the damage he had done. But when, without speaking, I picked up one of the torn shreds of the curtains, the terrier gave a howl, and, rushing out of the room, ran up-stairs screaming as loudly as he was able. The only interpretation I can assign to this conduct is, that, his former fit of passion having subsided, the dog was sorry at having done what he knew would annoy me; and, not being able to endure in my presence the remorse of his smitten conscience, he ran to the farthest corner of the house crying *peccavi* in the language of his nature.

I could give several other cases of conscientious action on the part of this terrier, but, as the present article is already too long, I shall confine myself to giving but one other case. This, however, is the

[1] A reproachful word or look from me, when it seemed to him that occasion required it, was enough to make this dog miserable for a whole day. I do not know what would have happened had I ventured to strike him; but once when I was away from home a friend used to take him out every day for a walk in the park. He always enjoyed his walks very much, and was now wholly dependent upon this gentleman for obtaining them. (He was once stolen in London through the complicity of my servants, and never after that would he go out by himself, or with any one he knew to be a servant.) Nevertheless, one day while he was amusing himself with another dog in the park, my friend, in order to persuade him to follow, struck him with a glove. The terrier looked up at his face with an astonished and indignant gaze, deliberately turned round, and trotted home. Next day he went out with my friend as before, but after he had gone a short distance he looked up at his face significantly, and again trotted home with a dignified air. After this my friend could never induce the terrier to go out with him again. It is remarkable, also, that this animal's sensitiveness was not only of a selfish kind, but extended itself in sympathy for others. Whenever he saw a man striking a dog, whether in the house or outside, near at hand or at a distance, he used to rush to the protection of his fellow, snarling and snapping in a most threatening way. Again, when driving with me in a dog-cart, he always used to seize the sleeve of my coat every time I touched the horse with the whip.

most unequivocal instance I have ever known of conscience being manifested by an animal.

I had had this dog for several years, and had never—even in his puppyhood—known him to steal. On the contrary, he used to make an excellent guard to protect property from other animals, servants, etc., even though these were his best friends.[1] Nevertheless, on one occasion he was very hungry, and, in the room where I was reading and he was sitting, there was, within easy reach, a savory mutton-chop. I was greatly surprised to see him stealthily remove this chop and take it under a sofa. However, I pretended not to observe what had occurred, and waited to see what would happen next. For fully a quarter of an hour this terrier remained under the sofa without making a sound, but doubtless enduring an agony of contending feelings. Eventually, however, conscience came off victorious, for, emerging from his place of concealment and carrying in his mouth the stolen chop, he came across the room and laid the tempting morsel at my feet. The moment he dropped the stolen property he bolted again under the sofa, and from this retreat no coaxing could charm him for several hours afterward. Moreover, when during that time he was spoken to or patted, he always turned away his head in a ludicrously conscience-stricken manner. Altogether I do not think it would be possible to imagine a more satisfactory exhibition of conscience by an animal than this; for it must be remembered, as already stated, that the particular animal in question was never beaten in its life.[2]—*Advance-sheets of the Quarterly Journal of Science.*

[1] I have seen this dog escort a donkey which had baskets on its back filled with apples. Although the dog did not know that he was being observed by anybody, he did his duty with the utmost faithfulness; for, every time the donkey turned back its head to take an apple out of the baskets, the dog snapped at its nose; and such was his watchfulness that, although his companion was keenly desirous of tasting some of the fruit, he never allowed him to get a single apple during the half-hour they were left together. I have also seen this terrier protecting meat from other terriers (his sons), which lived in the same house with him, and with which he was on the very best of terms. More curious still, I have seen him seize my wristbands while they were being worn by a friend to whom I temporarily lent them.

[2] This latter point is most important, because, although the moral sentiment in its incipient stages undoubtedly depends in a large measure upon fear of punishment, still, in its more developed state, this sentiment is as undoubtedly independent of such fear (Cf. Bain, "Mental and Moral Science," pp. 456–459, 1875); and forasmuch as in our analysis of animal psychology we can be guided only by the study of outward actions, and forasmuch as the course of action prompted by direct fear of punishment will nearly always be identical with that prompted by true conscience, it is of the first importance to obtain cases such as the above, in which mere dread of punishment cannot even be suspected to have been the motive principle of action.

AIR-GERMS AND SPONTANEOUS GENERATION.[1]

By P. SCHÜTZENBERGER.

THE question of the origin of ferments is intimately connected with that of spontaneous generation. In fact, from the time of Van Helmont and others, who, even in the seventeenth century, gave directions for the production of mice, frogs, eels, etc., the partisans of this mode of generation have, by the progress of the tendency to examine into the causes of things, been driven from the larger animals or plants visible to the naked eye, to the smallest living productions, which we can observe only by the aid of the microscope. But ferments are found among these inferior microscopic organisms. Redi, a member of the Academy of Cimento, showed that the worms in putrefied flesh, which were at first thought to be of spontaneous origin, are only the larvæ from the eggs of flies, and that all that was necessary, to prevent entirely the birth of these larvæ, was to surround the decomposing meat with fine gauze; he was the first to ascertain that parasitic animals are sexual and able to lay eggs.

The invention of the microscope, and the numerous observations by which it was followed, toward the end of the seventeenth, and the commencement of the eighteenth century, gave fresh impulse to the doctrine of spontaneous generation, which had lost all credit in questions concerning the origin of living beings of a higher order.

The question now was how to explain the origin of the various living productions, revealed by the microscope in infusions of vegetable and animal substances, among which no apparent symptom of sexual generation could then be found.

The subject was studied for the first time in a scientific manner by Needham, who published, in 1745, in London, a work on this subject. This observer did for infusoria what had already been done for the higher organisms. He protected, or rather endeavored to protect, vegetable or animal infusions from the action of germs, seeds, or any other agents of multiplication which could come from without. At the same time he destroyed by a physical agent, heat, the germs which might be supposed to exist beforehand in the liquid. Under these conditions, either living beings will be produced in the midst of the infusion, or none will be found there; in the former case, it must be admitted that these organisms are developed in the medium which is suitable to them, without the intervention of any germ; in the second, that the doctrine of spontaneous generation is false. In reality, the question can only be resolved in this manner, and all experimenters

[1] Abridged from "Schützenberger on Fermentations," No. XX. of the "International Scientific Series."

who have entered upon it from Needham's time to the present day ought to have made use of it.

The serious and grave difficulty, on which, during this period, all discussions raised between heterogenists and panspermists have turned, is so to arrange the experiments as to remove every suspicion of the intervention of germs brought from without, or preëxisting in the liquid.

If the result is negative, if when all precautions that seem to be necessary have been taken, and all causes of error have been removed, there is no formation of infusoria, it will be difficult to raise any serious objection to the inevitable conclusion, provided that the methods employed for the purpose of eliminating the preëxisting germs are not of such a nature as to modify the medium, and to render it unfit for the development and the nutrition of living organisms. If, on the contrary, we still meet with the birth of living beings, the suspicion will always revive that the experiment has been badly performed, and that a contrary result would have been obtained by conducting it more carefully. The heterogenists, therefore, find themselves in a more disadvantageous situation than their opponents, and, notwithstanding the success which they may obtain, they will never convince them.

We think, therefore, that it is useless to give here a detailed account of their minute researches; they must be consulted in the original memoirs. *A single experiment which proves, by a negative result, that organic infusions, protected from germs from without, do not give birth to infusoria, is worth more, scientifically speaking, than ten experiments tending to establish the contrary opinion.*

If, therefore, we pass over the details of the fundamental experiments of the heterogenists, and speak of those the results of which are conformable to the ideas of the panspermists, it will not be in a spirit of partiality. We are convinced that the latter are the only ones free from all objections, the relative skill of the operators being disregarded, and considered as nothing in the estimate formed. We may, however, say that M. Pasteur's researches may serve as a model for all those who may wish to conduct investigations of this kind, whatever may be the preconceived opinion by which they are guided. By their precision, and the care taken to remove every source of error, they leave nothing to be desired.

As the results obtained by M. Pasteur lead him to deny spontaneous generation, his opponents must above all prove that he is mistaken, by adopting the same rigorous experimental conditions. Needham's experiments, which led him to admit and sustain the doctrine of spontaneous generation, consisted essentially in placing organic substances which were capable of decomposition, in vessels hermetically sealed, which were subsequently submitted to a high temperature, in order to destroy the preëxisting germs. The work of the English writer attracted great notice on account of the support of Buffon,

whose ideas he upheld. Soon after began the great controversy between Needham and Spallanzani, who refuted, by experiment, the conclusions arrived at by Needham.

The controversy turned principally on this point: Spallanzani was not satisfied with heating the hermetically-sealed vessels containing the infusions, for several minutes, *merely the time which is required to cook a hen's-egg, and to destroy the germs*, as Needham expresses it, but he kept them for the space of an hour in boiling water. He then observed no production of infusoria. But, objects the English observer, from the manner in which he treated and put to the torture his nineteen vegetable infusions, it is evident that he not only much weakened, or perhaps totally destroyed, the *vegetative force* of the substances infused, but also entirely corrupted, by the exhalations and the odor of the fire, the small portion of air which remained in the empty part of his vessels. It is not, therefore, surprising that his infusions, thus treated, gave no signs of life. Such must necessarily have been the case. This idea, that the action of the temperature of boiling water destroys the vegetative force of infusions, is maintained even at the present day, and has served as an argument to the heterogenists; as they were unable to attack the material correctness of Pasteur's experiments, they did not accept the conclusions which he sought to derive from them.

We find also in the passage just cited, the necessity for the experiments made by Schwann and Helmholtz on calcined air, and for those of Schröder and F. Dusch, on strained air. The objection of a possible change in the air contained in the vial, under the influence of prolonged boiling, in presence of organic substances, was a serious one at the time that it was brought forward; it becomes more so, when we know that the air confined over preserved meats, prepared by Appert's process, contains no oxygen. It was, therefore, absolutely necessary to place the infusions in contact with air in a normal condition, after that boiling had deprived them of their preëxisting germs, avoiding at the same time any new germs brought by the air.

For this purpose, Dr. Schwann heated flasks containing the infusions, until the destruction of the germs was insured; but his flask was not closed: it communicated freely with the surrounding air by mean of a glass tube bent in the form of a U, and heated, in one part of its length, by means of a bath of fusible alloy. Under these conditions, the air may be renewed in the flasks, but the fresh atmospheric air admitted has undergone, like the infusion, the action of heat, which destroys the germs. Schwann's experiment was very decisive, as to broth made from meat; and the negative result (no development of infusoria) was quite satisfactory. But it was not the same with analogous trials on alcoholic fermentation, which gave contradictory results. Ure and Helmholtz repeated and multiplied these experiments with the same success.

To obviate the objection of a possible change by heat, in a mysterious and undefined principle, different from germs, but whose presence in the air was necessary to the production of infusoria, Schultze caused the renewed air to pass through energetic chemical reagents, such as concentrated sulphuric acid. He half filled a glass vessel with distilled water containing various animal and vegetable substances; then stopped the vessel with a cork through which passed two bent tubes, and exposed the apparatus thus arranged to the temperature of boiling water. Then, while the vapor was still escaping through the tubes, he adapted to each of them a Liebig's bulb apparatus, one containing concentrated sulphuric acid, and the other concentrated caustic potash. The high temperature must necessarily have destroyed every living thing, all the germs that might happen to be in the inside of the vessel, or of its appendages, and the communication from without was intercepted by the sulphuric acid on one side and the potassa on the other. Nevertheless, it was easy to renew, by aspiration at the end of the apparatus which contained the potassa, the air thus inclosed, and the fresh quantities of this fluid which were introduced could not carry with them any living germ, for they were forced to pass through a bath of concentrated sulphuric acid. M. Schultze placed the apparatus thus arranged at a well-lighted window, side by side with an open vessel, which contained an infusion of the same organic substances; then he was careful to renew the air in his apparatus several times a day for more than two months, and to examine with the microscope what took place in the infusion. The open vessel was soon found filled with vibrios and monads, to which were soon added polygastric infusoria of a larger size, and even rotifers; but by the most attentive observation he could not discover the least trace of infusoria, confervæ, or mildews, in the infusion contained in the apparatus.

The latest researches of Schröder and Von Dusch (1854–1859) tended to raise another objection, the possible change in a special principle in the air, by a reagent as energetic as sulphuric acid. Guided by the experiments of Loëwel, who ascertained that common air, when it had been previously filtered through cotton, was unfit to cause the crystallization of supersaturated solutions of sodium sulphate, they placed one of the tubes of Schultze's apparatus in communication with a tube 1.18 inch in diameter, and from 19.68 to 23.62 inches in length, filled with cotton-wool. The other tube was connected with an aspirator.

When the liquid, the interior of the flask, and the tubes, had been deprived of air by boiling, the apparatus was removed to its place, and the aspiration continued night and day. The two observers thus proved that meat, to which water had been added, the wort of beer, urine, starch, paste, and the various materials of milk taken separately, remained intact in the filtered air. On the contrary, milk, meat

without water, and the yolk of egg, grew putrid as rapidly as in common air.

The result of these experiments is, that there are spontaneous decompositions of organic substances which require nothing but the presence of oxygen gas to cause them to commence; while others need, besides oxygen, the presence in the atmospheric air of *those unknown things*, which are destroyed by heat or sulphuric acid, or are retained by the cotton.

The two observers do not then decide on the nature of these things, and do not assert categorically that they are germs, and, in reality, nothing allows us to draw these conclusions.

M. Pasteur's experiments have advanced the question another step, by proving that they are really germs of ferments and infusoria, which are destroyed by heat, or arrested by the sulphuric acid or cotton in the experiments alluded to above.

M. Pasteur made a hole in a window-shutter, several metres above the ground, and through this he passed a glass tube .196 inch in diameter, and containing a plug of soluble cotton .39 inch in length, kept in its place by a spiral platinum wire. One of the ends of this tube passed into the street; the other communicated with a continuous aspirator. When the air had passed for a sufficient time, the plug of cotton, more or less soiled by the dust which it had intercepted, was placed in a small tube with the mixture of alcohol and ether, which dissolves gun-cotton. It was left for the space of a day. All the dust was deposited at the bottom of the tube, where it is easy to wash it by decantation, without any loss, if care is taken to separate each washing by an interval of repose of from twelve to twenty hours. The deposit, and the liquid which covers it, are put in a watch-glass together; after the evaporation of the alcohol, the remainder is placed in water, and examined with the microscope. M. Pasteur also made use of ordinary sulphuric acid in order to moisten the dust. This agent had the effect of separating the grains of starch and calcium carbonate, which are always found in greater or less quantities in deposits collected on the plug of cotton.

FIGS. 1 AND 2.—ORGANIC CORPUSCLES OF DUST, MIXED WITH AMORPHOUS PARTICLES.

Figs. 1 and 2 represent organic corpuscles, associated with amorphous particles, as seen through the microscope, under a power of 350 diameters; the liquid containing them was common sulphuric acid.

Fig. 1 applies to dust collected from the 25th to the 26th of June, 1860; Fig. 2 to dust from the very intense fog of January, 1861.

It was not enough to discover with the microscope organic particles mixed with amorphous substances, but it was necessary to prove that these particles really consisted of fertile germs, capable of producing the infusoria which are developed in such abundance in organic liquids exposed to the air. For this purpose, M. Pasteur arranged the experiment in the following manner:

Into a flask capable of containing from 15 to 18 cubic inches, he introduced 6 to 9 cubic inches of albuminous saccharine water, prepared in the following proportions:

Water, 100;
Sugar, 10;
Albuminoid and mineral matter from beer-yeast, .2 to .7.

The neck of the drawn-out neck-flask communicated with a platinum tube, as shown in Fig. 3. In this first stage of the experiment the T-shaped tube with three stopcocks is removed, and its place supplied by a simple India-rubber connecting-piece. The platinum tube is raised to a red heat by means of a small gas-furnace. The liquid is boiled for two or three minutes, and is then allowed to grow completely cold. It is filled with common air, at the ordinary pressure of the atmosphere, but which has been wholly exposed to a red heat; then the neck of the flask is hermetically sealed.

This, being thus prepared and detached, is placed in a stove at a constant temperature of about 86° Fahr.; it may be kept there for any length of time without the least change in the liquid which it contains. It preserves its limpidity, its smell, and its weak acid reaction; even a very slight absorption of oxygen is mainly to be observed. M. Pasteur affirms that he never had a single experiment, which was arranged as described above, which yielded a doubtful result; while water of yeast mixed with sugar, and boiled for two or three minutes, and then exposed to the air, was already in evident process of decomposition in a day or two, and was found to be filled with bacteria and vibrios, or covered with mucors. These experiments are directly opposed to those of Messrs. Pousset, Mantegazzo, Joly, and Musset.

It is therefore clearly proved that sweetened yeast-water, a liquid very liable to be decomposed by the contact of common air, may be preserved for years unaltered when it has been exposed to the action of calcined air, after having been allowed to boil for a few minutes (two or three).[1]

This being determined, M. Pasteur adapted, by means of an India-rubber tube, the closed point of his flask filled with sweetened yeast-

[1] M. Pasteur has pointed out a cause of want of success, which has led many experimenters into error; by showing that the mercury of a mercurial trough is a complete receptacle for living organisms, and consequently that all experiments made with such a trough must necessarily induce a development of infusoria.

water, which had been kept for two or three months in a heated stove, without any development of organisms, to an apparatus arranged like that in Fig. 3.

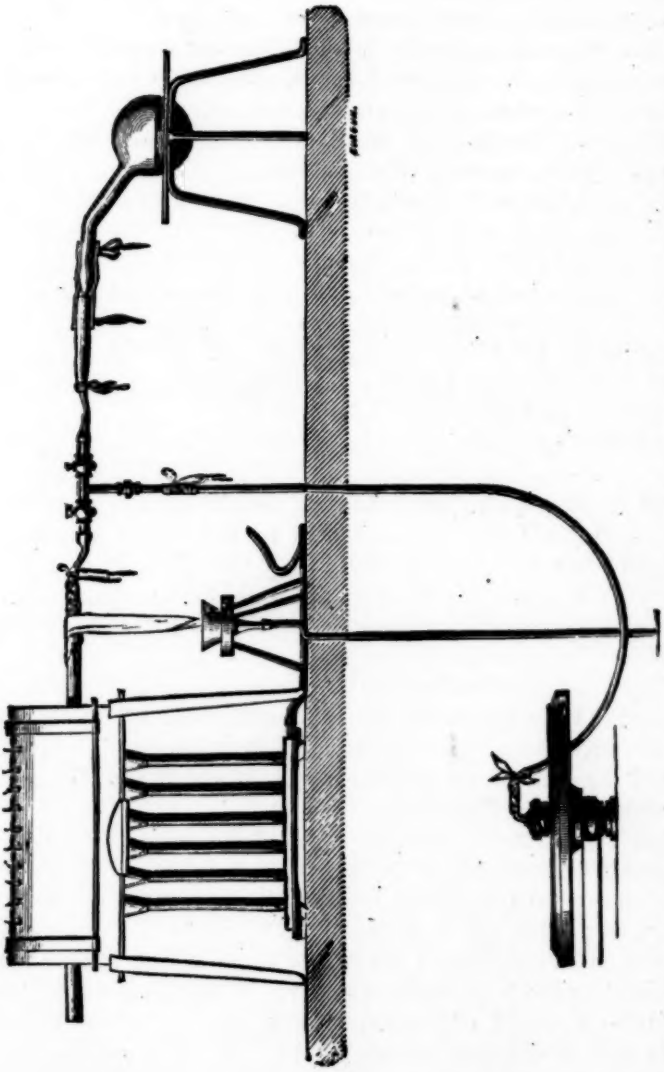


FIG. 3.—M. PASTEUR'S APPARATUS FOR THE INTRODUCTION OF CALCINED AIR INTO FLASKS CONTAINING ORGANIC INFUSIONS.

The pointed end of the flask passed into a strong glass tube .39 to 46 inch in its inner diameter, within which he had placed a piece of tube of small diameter, open at both ends, free to slip into the larger tube, and inclosing a portion of one of the small plugs of cotton loaded with dust. The larger glass tube is bound to a brass tube in form of a T, furnished with stopcocks, one of which communicates

with the air-pump, another with the heated platinum tube, and the third with the flask, by means of the large tube which contains the smaller one with the cotton. These various parts are joined together by means of India-rubber.

The experiment is commenced by exhausting the air, after having closed the stopcock connected with the red-hot metallic tube. This being afterward opened, allows calcined air to enter the tubes slowly; this operation (exhaustion and readmission of calcined air) is repeated several times. The point of the flask is then broken off within the India-rubber, and the small tube containing the dust is allowed to slip into the flask, the neck of which is again sealed with the lamp. As an additional proof, and to obviate all objections, the same arrangements were made with similar flasks, prepared like the preceding, but with this difference that, instead of cotton charged with atmospheric dust, there was substituted a small piece of tube containing calcined asbestos (as an additional precaution, it had been ascertained that calcined asbestos, loaded with atmospheric dust, by the same means as the cotton, gave identical results).

The following are the observations obtained constantly by M. Pasteur:

In all the flasks, into which dust collected from the air was introduced—1. Organic productions began to make their appearance in the liquid after twenty-four, thirty-six, or forty-eight hours at the most. This was precisely the time necessary for the same phenomena to appear in sweetened yeast-water exposed to contact with the atmosphere.

2. The products observed are of the same kind as those which are seen to make their appearance in the liquid when left freely exposed to the air, such as mucors, common mucidines, torulacei, bacteria, and vibrios of the smallest species, the largest of which, the *Monas lens*, is only .000157 inch in diameter.

When the water of yeast is replaced by urine, the experiment being conducted exactly in the same manner, we always notice the absence of any change as long as atmospheric dust has not been introduced, while, with the addition of this, numerous organisms are developed, in every respect similar to those which appear and are developed in urine kept in the open air. If, on the contrary, the experiment be repeated with common milk, we may be sure that it will in every case curdle, and become putrid. We shall observe the birth of numerous vibrios of the same species, and bacteria, and the oxygen of the flask will disappear. M. Pasteur thinks that this result, so different from those observed in other liquids, arises only from the fact that milk contains germs of vibrjos which resist the boiling heat of water. To prove this, he boiled milk, not at 212° Fahr., or at the usual pressure of the atmosphere, but at 230° Fahr., under a greater pressure, and he found that the flasks thus prepared, and hermetically sealed,

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could be kept for an indefinite time in the stove, without giving rise to the smallest production of mould or infusoria. The milk preserves its taste, its smell, and all its properties; and the atmosphere of the flask is only slightly modified in its composition. This difference be-

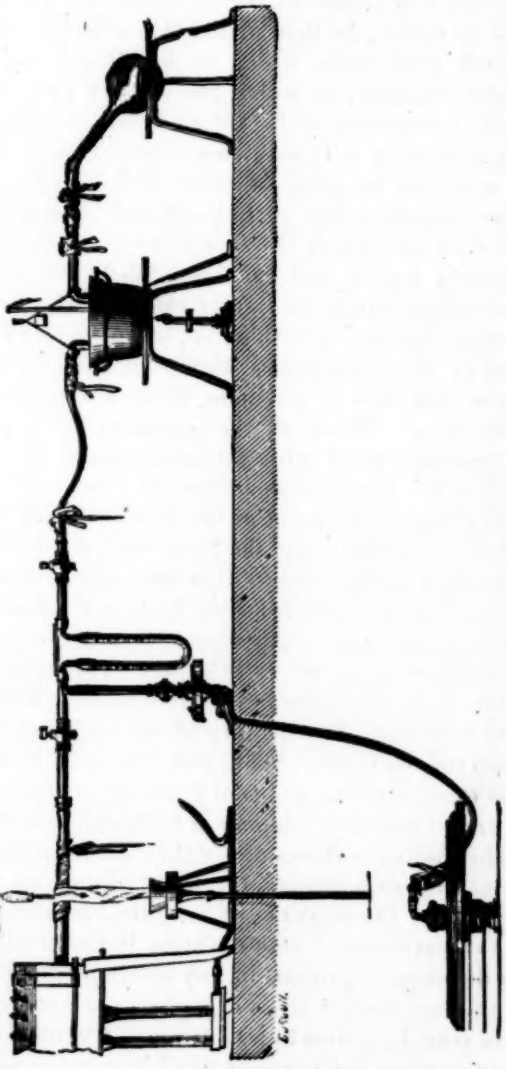

FIG. 4.—M. PASTEUR'S APPARATUS FOR STUDYING THE RESISTANCE OF GERMS AND SPORES TO TEMPERATURES MORE OR LESS ELEVATED.

tween milk and urine, or sweetened yeast-water, must be attributed to the alkaline condition of the former medium, whereas the two others are acid. In fact, if we previously neutralize the acid of the sweetened yeast-water, by means of calcium carbonate, we obtain organisms under the same conditions of the experiment as those under which they were not before developed.

U of M

These facts led M. Pasteur to make researches on the comparative action of temperature on the fecundity of the spores of the mucidines, and of the germs which exist suspended in the atmosphere.

The following is, in few words, the method followed by him: He passed a small portion of asbestos over the small heads of the moulds which he wished to study; he then placed this asbestos, covered with spores, in a small glass tube, which he introduced into a U-tube (Fig. 4) of larger diameter, in which the smaller tube could move freely; one of the extremities of the U-tube is joined by India-rubber to a metal tube in form of a T, with stopcocks. One of these cocks communicated with the air-pump, another with a red-hot platinum tube. The other extremity has an India-rubber tube which is connected with the flask into which the spores are to be introduced; this flask is hermetically sealed, and has been filled with calcined air, and suitable nutritious liquid previously raised to the boiling-point. Finally, the U-tube dips into a bath of oil, of common water, or salt-water, according to the temperature which we wish to attain. Between the U-tube and that of platinum, there is a drying-tube with sulphuric pumice-stone. When all the apparatus which precedes the platinum tube has been filled with calcined air, and the spores have been maintained at the desired temperature for a sufficient time, which may be varied at pleasure, the point of the flask is broken with a blow of a hammer, without unfastening the India-rubber connecting-pieces which attach the flask to the U-tube; then inclining to a proper angle this latter tube, when removed from its bath, the asbestos with its spores is slipped into the flask. The flask is then hermetically sealed, and is carried to the stove at 68° to 86° Fahr. The experiment with the dust from the air is also made in the same manner with asbestos.

Without any humidity, the fecundity of the spores of *Penecillium glaucum* is preserved up to 248° Fahr., and even a little above—257° Fahr. It is the same with the spores of the other common mucidines. At 266° Fahr., the power of developing or multiplying is destroyed in all of them. The limits are the same for the dust from the air.

In all these careful experiments, the most scrupulous precautions were taken to prevent the access of the slightest portion of common air. But, say the partisans of heterogenesis, if the smallest portion of common air develops organisms in any infusion whatever, it must necessarily be the case that, if these organisms are not spontaneously generated, there must be germs of a multitude of various productions in this portion of common air, however small it may be; and, if things were so, the ordinary air would be loaded with organic matter, which would form a thick mist in it.

M. Pasteur has shown that there is a great deal of exaggeration in the opinion that even the smallest quantity of air is sufficient to develop multitudes of organisms; that, on the contrary, there is not in the atmosphere a continuous cause of these so-called spontaneous gen-

erations; that it is always possible to procure, in any determined place, a limited quantity of common air, having undergone no kind of modification, whether physical or chemical, and nevertheless quite unsuited to set up any decomposing action in a liquid eminently putrescible. The method of experimenting is very simple. Into a flask of 15 to 18 cubic inches, 9 cubic inches of a liquid that has a tendency to decomposition are introduced; the neck of the flask is drawn out with the lamp, leaving the point open; then the liquid is boiled till the vapor escaping from the extremity has expelled all the air; at this moment the point of the flask is closed by the lamp, by means of a blowpipe, and it is allowed to grow cool. The flask then contains no air; if we break off the point in any particular place, the air reënters suddenly, carrying into it the germs held in suspension; it is again closed with the lamp, and kept in a stove at a temperature of 68° to 86° Fahr. In the generality of cases, organisms are developed; these organisms are even more varied than if the liquid were freely exposed to the air, which M. Pasteur explains by saying that, in this case, the germs in small number, in a limited volume of air, are not hindered in their development by germs in greater number or more precocious in their fecundity, which are able to occupy the space, and leave no room for them. But it is especially important to notice in the results obtained by this method, what frequently happens many times in each series of trials, that the liquid continues absolutely intact, however long it may have remained in the stove, as if it had been filled with calcined air. This phenomenon is the more striking, and shows itself in more marked proportions, when the air received into the flasks is taken from a greater height. Thus, among twenty flasks opened in the country, eight contained organic productions; out of twenty opened on the Jura, only five contained any; and out of twenty flasks opened at Montanvert, in a rather high wind, blowing from the deepest gorges of the "Glacier des Bois," only one was affected by any change.

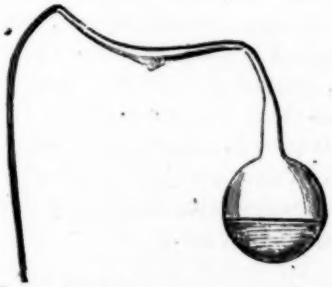

FIG. 28.—M. PASTEUR'S FLASK TO DEPRIVE THE AIR OF ITS GERMS.

We may also draw other conclusions from this series of observations. Since the putrescible liquid, which had been previously boiled, and which was contained in the flasks, was filled with organic produc-

tions in a great number of instances, after the introduction of a limited quantity of air, the genetic power of the infusions had not been destroyed by the material conditions of the experiments. Besides, this objection, which has been raised ever since the earliest controversies between the heterogenists and the panspermists, has been definitely answered by an experiment made by M. Pasteur; he received in a flask, exhausted and deprived of living germs by the momentary application of a sufficiently high temperature, some blood at the instant that it left the organism, and without allowing this liquid, which is so peculiarly putrescible, to come in contact with air. By permitting air deprived of germs, either by calcination or simple filtration, to enter the flask, and then hermetically sealing it, he found that the blood was preserved for an indefinite period intact, although it had not been exposed to heat.

M. Pasteur has also shown that air may be deprived of germs by its passage through a capillary tube bent upon itself. It is, therefore, sufficient, in most cases, to draw out the neck of the flask so as to form a very long, narrow tube, which is bent in several directions, as, for example, in Fig. 5. When the air originally contained in it has been expelled, and the preëxisting germs killed by prolonged boiling, the flask is allowed to cool slowly.

In closing our account of M. Pasteur's interesting memoir, in which heterogenesis was driven to its last intrenchments, we must add that this learned chemist endeavored to deprive his adversaries of one of their principal arguments. Experiments on spontaneous generation have always been conducted with vegetable or animal infusions; it was supposed by Needham, Buffon, and Pouchet, that organisms were only thus produced at the moment of expiring Nature, when the elements of the beings on which they are developed are entering into new chemical combinations, and are passing fully through the phenomena of fermentation or putrefaction.

In other words, albuminoid matters preserve in some degree a certain reserve of vitality, which would allow them to become organic by contact with oxygen, when the conditions of temperature and humidity are favorable. Starting with the idea that albuminoid substances are only aliments for the germs of infusoria, mucidines, or ferments, M. Pasteur has proved directly that organic substances may be replaced by those which are purely mineral or artificial, or, at least, by substances on which this imaginary vegetative force cannot be supposed to have any influence.

SKETCH OF DR. AUSTIN FLINT, JR.

THIS gentleman has won his scientific eminence in the field of physiology. Though but forty years of age, he has attained the highest rank in his chosen department as an experimental inquirer, teacher, and author—having published the most elaborate treatise upon the subject of physiology in the English language.

The name of Flint is now famous in the medical world through the celebrity of both father and son; but there is probably a factor of inherited genius in this line which goes to their making up, for they have come from a long race of doctors. This is the genetic line of the generations of medical Flints, so far as Americans will be interested to know it. They are descended from Thomas Flint, who came from Matlock, Derbyshire, England, in 1638, and settled in Concord, Massachusetts. Edward Flint, physician of Shrewsbury, Mass., was father of the great-grandfather of the subject of this sketch. The great-grandfather, Austin Flint, after whom the contemporary Flints are named, was a physician who died at Leicester, Massachusetts, in 1850, over ninety years of age. He served as a private soldier and afterward as a surgeon in the Revolutionary War. The grandfather of Austin, Jr., was Joseph Henshaw Flint, a distinguished surgeon of Northampton, Massachusetts, and afterward of Springfield, in the same State. His father is Austin Flint, now an eminent physician in New York City. He was born at Petersham, Massachusetts, in 1812, and graduated M. D. at Harvard, in 1833. He is a voluminous author and a distinguished practitioner.

AUSTIN FLINT, Jr., was born at Northampton, Massachusetts, March 28, 1836, and his parents removed to Buffalo, New York, in the same year. He was educated at private schools in that city, and, when fifteen, he spent a year in the Academy of Leicester, Massachusetts. He prepared for college at Buffalo, and entered Harvard University as Freshman in 1852. He left the university in 1853, and spent a year in the study of civil-engineering. He began the study of medicine in the spring of 1854 at Buffalo, and attended two courses of lectures at the medical department of the University of Louisville (1854–'55 and 1855–'56). His taste for physiology was early developed, and he made some experiments on living animals for Prof. Yandell, of the Louisville school, while he was a student there. His final course of lectures was taken at Jefferson Medical College, Philadelphia, in 1856–'57, and at the close of the course he graduated. His inaugural thesis on the "Phenomena of the Capillary Circulation" was honored with the recommendation to be published, and appeared in the *American Journal of Medical Sciences* in July, 1857. It was based upon numerous original experiments. He was editor for three years (1857–'60)

of the Buffalo *Medical Journal*, which was founded by his father in 1846, and ultimately transferred to New York and merged in the *American Medical Monthly*.

In 1858 Dr. Flint was appointed one of the attending surgeons of the Buffalo City Hospital. The same year he became Professor of Physiology in the Medical School of Buffalo. In 1859 he removed with his father, and was appointed Professor of Physiology in the New York Medical College, delivering a course of lectures in 1859–'60. In 1860 he received the appointment of Professor of Physiology in the New Orleans School of Medicine, delivered a course of instructions in 1860–'61, and resigned the position at the breaking out of the war. While in New Orleans he experimented on alligators, and developed some important points with reference to the influence of the pneumogastric nerves upon the heart. He also made some experiments there upon the recurrent sensibility of the anterior roots of the spinal nerves. He was the first physiologist in this country to operate upon the spinal cord and the spinal nerves in living animals.

In the spring of 1861 Dr. Flint went to Europe, and studied several months with Charles Robin and Claude Bernard, with the former of whom he had close friendly and scientific relations, and maintained a frequent correspondence. Prof. Robin presented his memoir, "Sur une nouvelle fonction au foie" ("On a New Function of the Liver"), to the French Academy of Sciences for the Monthyon prize without the knowledge of the author. In 1863 Dr. Flint made some important experiments upon the blood, employing a new mode of analysis for its nitrogenized constituents. He was one of the founders of the Bellevue Hospital Medical College, in 1861, and has been from the first, as he still is, Professor of Physiology and Secretary and Treasurer of the Faculty. He was also for eight years Professor and Lecturer on Physiology in the Long Island College Hospital of Brooklyn.

In 1862 Dr. Flint made some remarkable observations on the excretory function of the liver, published in the *American Journal of the Medical Sciences*, in October, 1863; translated into French, and presented by Robin to the French Academy of Sciences for the "*Concours Monthyon*," and which received honorable mention and a recompense to the author of 1,500 francs in 1869. The important discovery put forth in this memoir was the production of cholesterine in the physiological wear of the brain and nervous tissue, the elimination of cholesterine by the liver, and its discharge in the form of stercorine in the fæces. It was established that the new substance (stercorine) results from the transformation of cholesterine in the fæces. The diseased condition caused by the retention of cholesterine in the blood (cholesteræmia) is now recognized as a very important pathological fact. Dr. Flint's laborious researches and interesting conclusions upon this subject have been lately confirmed in Germany by experiments

in which cholesteræmia has been produced in animals by injection of cholesterine into the blood.

In 1867, at the request of the Commissioners of Public Charities and Correction of New York City, Dr. Flint reorganized the dietary system for the institutions under their charge, including Bellevue Hospital, Charity Hospital, Poorhouse, Workhouse, Penitentiary, etc., etc., making diet-tables for more than 10,000 persons. In 1871 he made observations upon Weston, the pedestrian, analyzing his food and secretions for fifteen days before, during, and after one of his great walking-exploits. These inquiries help to decide some important physiological questions.

In 1869 Dr. Flint published an elaborate review of the history of the discovery of the motor and sensory properties of the roots of the spinal nerves, in which the discovery was ascribed to Magendie instead of to Sir Charles Bell, who has generally been regarded as its author. This review, originally published in the *Journal of Psychological Medicine*, New York, in 1868, was translated into French, and published in Robin's *Journal de l'anatomie.* It produced such an impression that it was soon followed by the publication, in the English *Journal of Anatomy*, of the original paper of Charles Bell, "Idea of a New Anatomy of the Brain," which was privately printed (not published) in 1811. The original manuscript was furnished to the *Journal of Anatomy* by the widow of Sir Charles Bell. It was upon this paper that the claims of Charles Bell to the discovery were based; and, before its publication in the *Journal of Anatomy*, it had been entirely inaccessible.

Claude Bernard has been the eminent advocate of the theory that the liver is a sugar-producing organ; but observations upon this subject were discordant, and eminent physiologists contested Bernard's position. In 1869 Dr. Flint published, in the NEW YORK MEDICAL JOURNAL, a series of experiments upon the "glycogenic function of the liver," in which he endeavored to harmonize the various conflicting observations, and is considered by most physiologists to have settled the question.

In 1866 he announced the publication of the "Physiology of Man," a work in five volumes, of 500 pages each, and the last volume was issued in 1874. He printed a little work in 1870 on "Chemical Examinations of Urine in Disease," which went through several editions. He contributed the articles on gymnastics and pugilism to the "American Cyclopædia," was appointed Surgeon-General of the State of New York by Governor Tilden in 1874, and has recently published a voluminous "Text-book of Human Physiology." He has also written much for scientific periodicals and popular journals, and has been actively engaged in his duties as a physiological teacher.

EDITOR'S TABLE.

THE NEW DEPARTURE AT THE CENTENNIAL EXHIBITION.

WE print the report of Commissioner Beckwith on the plan that has been adopted for the distribution of awards to exhibitors at the Philadelphia Exposition. In this matter the Centennial Commissioners have taken a new and very important step in advance of previous practice. The report is significant, as indicating a departure from the precedents of all former international exhibitions in a fundamental and perhaps the most important feature of their management. The system of gold medals and special prizes heretofore adopted has been abandoned, and articles of exhibition are to go upon their merits, as determined by competent judges from this country and abroad, and who will be responsible to the public for the opinions they give by signing their names to the published reports. This is a victory of honest good sense over former bad practices, which is most encouraging, and deserving of the heartiest commendation.

International expositions are new things in the world's experience. That is, they are new, as enormous extensions of local fairs and exhibitions which have been long in vogue. The primary idea was to bring all kinds of products together for public inspection and purchase. The show-element gradually became predominant, and the fair grew into an exhibition. The collection of rival commodities naturally led to competition, and this to committees of judgment or juries, which gave premiums for articles of the greatest excellence. Medals of gold, silver, and bronze, were assigned as testimonials of excellence in the articles approved. When the exhibitions grew into their great international proportions, this old method of awards was continued. But it was a very imperfect method, and its evils came out conspicuously in the great shows of London, Paris, and Vienna. The plan of granting graded medals is necessarily crude and inadequate; for, even if the awards are made upon the best judgment of the juries, they tell nothing, and are besides arbitrary and misleading. The differences among competing articles, in most cases, will not be as marked as the gradation of medals implies; so that their award will necessarily work injustice. There may be a score of products of the same kind, each, perhaps, with special merits, and none conspicuously preëminent; so that a gold medal awarded to one will greatly exaggerate its claims, and grossly wrong its rivals.

But this is not all, nor the worst. Medals become valuable and are eagerly sought because of the very injustice they work. To crown a single article, casts virtual reproach upon all its competitors; and hence the gold medal which exalts one thing and disparages all in rivalry with it is striven for with desperate eagerness by exhibitors on account of the commercial advantages that follow. The door is thus opened to every form of illegitimate influence that can be brought to bear upon the judges. The prizes to be won, being of enormous value, are fought for with such a reckless disregard of the means employed that men of integrity often quit the juries in disgust rather than be implicated in their corrupt proceedings. How great the strain must be, in many cases, is apparent when we reflect that, if the old system were in operation at the Philadelphia Exposition, there would probably be many exhibitors who could

afford to pay, each a million dollars, to secure the gold medal that would place their articles in advance of all competitors. Nor is there anything in recent American experiences that would justify us in expecting an incorruptible administration of the duties of jurymen. Even where the distribution of medals is supplemented and corrected by written reports the results must be unsatisfactory, for it is of small moment to the public that the award has been qualified or contradicted in a printed document. The verdict of the medal itself will be held as the important and decisive thing. Mr. Beckwith, who has not only had experience of the old practice, but has carefully studied its general workings, points out in his report the inadequacy of the European jury system and the defectiveness of its results. Profiting by these failures, the Philadelphia plan has been organized to avoid them, and give us more valuable and trustworthy work.

The first purpose of such a collection of the products of art, science, and industry, as will be displayed in Philadelphia, undoubtedly is, that its objects may be seen and inspected by the public; yet the mere gratification of curiosity by staring at new and strange things is certainly its lowest advantage. Such exhibitions are only put to their best and proper use as means of public education, in which observers become inquirers, and get a knowledge of the true qualities and characters of the things exhibited. The value of the display will be in proportion to its intelligent appreciation, and the management of the affair must be judged by the efficiency and completeness of the means adopted to instruct the public in regard to it. To this end, the first step was to get rid of the misguiding and vicious system of medals, and then to secure capable men to furnish discriminating and responsible reports. It is well for the national honor and for wholesome public influence that the most efficient measures have been taken to put things for once upon their naked and sterling merits. The selection of a hundred able experts from abroad, with a hundred more to be furnished by this country as judges, who are to be paid their personal expenses, and who are committed by their reputations to give honest and competent verdicts on the intrinsic and comparative merits of objects exhibited—the reports to be published for the use of visitors at the earliest practicable moment—is a measure on the part of the commissioners at once so sensible and so just that it raises some perplexity as to how it has been brought about. The old method of proceeding is so rooted in universal usage, and so congenial with the fierce competitive spirit of American business, that we cannot for a moment suppose it has failed to make its best fight against this innovation. That it should have been beaten, and a greatly superior method adopted by the commissioners, is alike unexpected and a cause of devout gratitude.

But the policy initiated at Philadelphia has a still further significance. It is not merely a transient expedient in the tactics of a great show, but it declares a principle of wide and permanent application in society. Its adoption strikes a blow at the all-prevailing habit of offering prizes as artificial stimulants to effort, instead of making the intrinsic excellence of work and its intelligent appreciation the true impulse of exertion and enterprise. Competitions are inflamed in all directions by sordid and selfish temptations, but it is in education that the system of extrinsic rewards and factitious provocations is carried to the greatest extent, and leads to the most mischievous results. The practice of giving prizes in schools is vicious as substituting spurious and unworthy motives to exertion, where the very object is to form the character by bringing generous and ennobling incitements into habitual and controlling exercise. To beat an antagonist, and win a medal or a purse,

is a vulgar and sordid inducement to study, and convicts the school that resorts to it of inefficiency in its legitimate and most essential work. It is, moreover, an injurious agency in education, as it is constantly used to stimulate students in false directions, and to the excessive cultivation of unimportant subjects. Our education is in a state of chaos in regard to the relative values of different kinds of knowledge. The waste of time and effort over comparatively worthless studies is something quite appalling, and it is everywhere aggravated by plying scholars with premiums for special attainments. Rich blockheads, with narrow notions and tenacious crotchets, smitten with the vanity of becoming public benefactors, go into the schools and found prizes and medals which set the students to racing in any direction which the whim or caprice of the donor may indicate. This evil is confessed, and has become so glaring that some institutions have wisely put a stop to such interference. But, as it is driven from the schools, it is taken up by outsiders, as we have seen in the intercollegiate contests that have lately come into vogue. Against this whole system the Philadelphia policy, as presented in Mr. Beckwith's report, is a tacit but powerful protest. To get things upon their real merits is a victory anywhere —to do this upon a great, unprecedented national occasion is a triumph—but there is no reason for adopting the principle in an exhibition of the products of manufacture that will not apply with increasing force to the management of educational establishments.

JUDGE DALY'S ADDRESS.

It is not easy to deal with the annual presidential addresses of Charles P. Daly before the Geographical Society. They are so fresh, readable, and full of novel and instructive matter, that there is a temptation to reprint them bodily. We have formerly spoiled them by summarizing; this year we publish in full the introductory portion, in which he glances at the achievements of geographical explorers during the third quarter of the nineteenth century ending in 1875, and shows what the state of things was at the beginning of that age, and what it is now. The main portion of the address, however, is devoted to an account of the researches, discoveries, and geographical work, of the past year. We are tempted to make some further use of Judge Daly's labors, which may incite our readers to procure the full address and read it themselves. Beginning with what has been done in our own country, President Daly sums up the results of the various exploring expeditions and surveys undertaken or aided by the Government, in the great Western, Northwestern, and Southwestern tracts of the continent. The results are varied and interesting. In the prehistoric section, on the ancient inhabitants of America, the evidence has been much extended in regard to the life of the old race of mound-builders. In reference to the antiquity of man on this continent, it is remarked:

"Prof. J. D. Whitney, from the remains found by him in California, is of the opinion that man existed there as long ago as the Tertiary period; that he was then the maker of instruments for grinding corn, as well as other implements of stone, and, as far as the examination of the imperfect skull which was found warrants a conclusion, that he was, at that remote period, the same anatomically that he is now. These discoveries of Prof. Whitney's go to show that man existed during the Glacial epoch, which is confirmed after seven years' examination of the deposits in the Victoria Cave, in England, and by recent discoveries in the inter-glacial coal-beds of Switzerland. The Glacial epoch is computed by Mr. Croll, in his recent work, to have ended about 80,000 years ago; and Mr. Croll is not only one of the best authorities, but the one whose estimate of the time is the lowest."

The work of arctic exploration continues to be vigorously pushed, and with promising results. A point of interest

is, that the English and German geographers have abandoned the routes they formerly advocated, and have, with great unanimity, united in recommending that the English expedition which left last June, under the command of Captain Nares, should go through Smith's Sound, following up the track of Kane, Hayes, and Hall —the route that has been uniformly urged by the American Geographical Society as the best. At a crowded meeting of the Royal Geographical Society, at which the officers of the expedition and most of the distinguished arctic explorers were present, the American theory of polar approach was heartily commended:

"Admiral Ommanny, formerly a prominent opponent of the route now adopted, also said that England must be grateful to her American cousins, who had cleared the way by successful operations through Smith Sound. When it is remembered that our early efforts in this direction were ignored, that the name of Grinnell Land, in Wellington Channel, was at first omitted upon English maps, and the name of a subsequent English explorer substituted, that our route by the way of Smith Sound received little support except from Admiral Sherard Osborn, Admiral Inglefield, and Mr. Clements R. Markham, this change of opinion and hearty recognition now are very gratifying, especially to our member, Dr. Hayes, the only one of our exploring commanders in the Arctic who is now alive."

To show that, in this boasted scientific age, geographical notions are still entertained as crude as those held five hundred years ago, Judge Daly gives an account of some of the theories that are still seriously advocated. One of these is described as follows:

"About the year 1819, Captain J. C. Symmes, an officer of the regular Army of the United States, advanced a theory, to the propagation of which he devoted the remainder of his life, that the earth was hollow, was inhabited within, and had an opening at the pole, which became known throughout the country as 'Symmes's Hole.' He pressed the subject upon Congress, urged an expedition to the pole to test his theory, and a Russian gentleman is said to have offered to fit one out if Symmes would conduct it under the auspices of Russia, which the captain declined, on the ground that the honor of establishing the theory should belong to the United States. He went over the country, delivering lectures in support of this theory, in which he firmly believed to the day of his death. His son, now an old man, has revived it, and is advocating it, as his father did, by delivering public lectures. The father's theory was, that this hole or opening in the Arctic was about one thousand miles in diameter, and somewhat wider at the Antarctic; and now that we have reached within five hundred miles of the arctic pole, about half of the assumed diameter of the supposed hole, without any indication so far of its existence, the son believes that if Captain Hall had got several degrees farther north he would have found evidence of the truth of the theory.

"Captain Hall startled us at the reception given to him and his officers by this Society, before the departure of the Polaris, by announcing publicly to us his belief in the existence of this hole, and of his determination to go in pursuit of it; a belief which, being an uneducated man, and but little acquainted with the geography of the Arctic, was firmly fixed in his mind. It was in pursuit of this supposed hole that he meant to attempt the passage to the pole by the way of Jones's Sound. I pointed out to him the impracticability of an attempt through Jones's Sound, and urged him to go as Kane and Hayes had done, by the way of Smith Sound, which course he ultimately adopted when advised to the same effect by Baron van Otten of the Swedish Expedition, whom he met during his voyage at Holsteinberg in Davis Strait.

"In a letter put forth last February, by Mr. Symmes, he not only argues that the earth is hollow, but that it has as much inhabitable surface within as without. He imagines that the inside is inhabited by human beings who are the progenitors of the white race, now upon the outer surface, and that there are apertures at the poles four or more hundred miles in diameter. This recalls the belief as to the cause of the earth's motion in the middle ages, when it became apparent from the researches of Copernicus and Galileo that it revolved upon its axis, which accounted for the motion by supposing that the interior of the earth was hollow, and was the place to which the damned were condemned, who produced the motion by their continual attempts to climb up the inside of this hollow ball in their fruitless

efforts to get out. A woodcut representing this strange belief will be found in an old cosmography in our library."

Meteorological and earthquake disturbances of the past year are noted; and, with an account of the voyage of the Challenger and the important results attained by it, Judge Daly passes to the progress of geographical work in Europe, and gives an instructive account of the drainage of the Zuyder Zee now undertaken by the people of Holland, who have become masters of hydraulics by necessity, as their whole country lies twelve feet below the level of the sea. They drained the Haarlem Lake, twelve miles long, seven miles wide, and fourteen feet deep, and covered it with thriving farms and villages, and were so pleased with the speculation that they have now undertaken to drain off the Zuyder Zee, which embraces an area of 759 square miles, and by which they propose to add six per cent. of fertile land to the total area of the country. It is a dull waste of half-navigable waters with low, marshy borders. They are first to construct an immense dike 164 feet wide at the bottom of the sea, and rising to a height of twenty-six feet above it, making a total length of wall, near the narrow opening of the sea, twenty-five statute miles. The inclosed area will be divided into squares, and pumped out at an expense of $48,000,000, or about $100 an acre. Our Yankees, who are being drowned by the score in the overflow of their ponds, might learn something about dams from these Dutchmen.

The president next attacks Asia, and gives us a great deal of valuable information of the results of geographical inquiry in various portions of its immense area, of which the following has a very human interest:

"Mr. Bond, of the Indian Trigonometrical Survey, discovered two of the wild dwarfish race who live in the hill-jungles of the Western Gàlitz, to the southwest of the Palini Hills, a race which, though often heard of, no trace of had previously been found by the survey. A man and a woman were discovered The man was four feet six inches high, and. 26½ inches about the chest. He had a round head with coarse, black, woolly hair and dark-brown skin, a forehead low and slightly retreating, the lower part of the face projecting like that of a monkey, with thick lips, protruding about an inch beyond his nose; a comparatively long body for his size, with short, bandy legs, and arms extending almost to his knees. The hands and fingers were so contracted that they could not be made to stretch out straight and flat. The palms and fingers were covered with a thick skin, particularly the tips of the fingers, the nails being small and imperfect, and the feet broad and thick-skinned all over. He had a grayish-white, scanty, coarse mustache like bristles, but no beard. The woman, who was about of the same size, was of yellow tint, with long, black, straight hair, and features well formed as contrasted with those of the man, there being no difference between her appearance and that of the common women of that part of the country. She had an agreeable expression, was well developed and modest. Their simple dress was a loose cloth, and, though they ate flesh, they lived chiefly on roots and honey. They have no fixed dwelling-places, but sleep between rocks, or in caves, near which they happen to be at night, when they light a fire and cook what they have collected during the day, maintaining the fire during the night for warmth, and to keep off wild animals. Their religion, such as they have, is the worship of certain local divinities of the forest. This is a new pygmy race, resembling the African Obongos of Du Chaillu, the Akkas of Schweinfurth, and the Dokos of Dr. Krapf, in their size, appearance and habits."

Africa is, however, now the great point of assault by geographical explorers, and there come the most wonderful revelations regarding the fertility and beauty of various of its extensive regions, with curious descriptions of its government and peoples. Dr. Nachtigal, describing Wadai, in Northeast Africa—

"Fixes the population of the country at about two and a half millions, and says that the surface elevation of the land is from west to east, with an elevation of from 1,000 to 1,500 feet above the sea-level. Numerous small streams flow from the eastern heights, falling into the two principal rivers, the Kafa and Peaka. The country is divided

into seven provinces; the religion is Mohammedan, and the king, whose power is arbitrary, is looked upon as a sort of divinity. The king's harem consists of about 500 wives, and all his sons, except the heir to the throne, are blinded with hot irons, a duty performed by the king of the smiths, who is also the surgeon of the harem. The people are skillful workers in iron, but given to the drinking of an intoxicating beer, a practice which great efforts are made to repress. Spies are extensively employed for that purpose, and any man upon whose premises the forbidden liquor is found is punished by having his wife's head shaved. The king has an army of 40,000 infantry and 6,000 cavalry, and the country is heavily taxed for the support of the king and his expensive government."

Judge Daly quietly compares our own "best Government on the face of the earth" with one of these African governments, and finds the comparison "not complimentary to our intelligence." Here is the passage:

"The Egyptian Geographical Society, under the presidency of Dr. G. Schweinfurth, the distinguished African explorer, was established this year at Cairo, through the liberality of the Khedive, consisting of 300 members, with an annual income of $7,000. A substantial portion of this income is granted by the Government in view of the advantages to the nation of the labors of the Geographical Society, as is the case with several of the leading Geographical Societies of Europe. But it would be hard to convince our Government of the utility of aiding, by pecuniary means, our Society, the only one in this country, when it would not even incur the expense of sending a commissioner to the late great Geographical Congress at Paris, and to our shame we were the only civilized nation that was unrepresented in the exposition. It is not complimentary to our intelligence and our cosmopolitan relations to the world, of which we form so important a part, that we have a Government that takes no interest in the advance of civilization, and of the trade, commerce, and industry of the world at large, through geographical exploration and discovery, the means by which it has been chiefly advanced, from the dawn of civilization to the present time. It was not the fault of this Society that our country was not represented in the exposition, for earnest efforts were made by us as well as by the French minister, but were met by the reply that the Congress in Paris was the affair of a private society, which was not the view taken by the other civilized nations, who made liberal grants of money for the success of an undertaking in which the whole world was interested. With our limited means, all that we could do was to send a delegation, as nothing could be received for exhibition except under the charge of a commissioner of the government of the country from which it was sent. If the gentlemen charged with the administration of our Government read the frequent expressions of surprise that I have read in the various accounts written of the exposition, at the absence of any representation from the United States, they would not, I think, be very much impressed with the wisdom and policy of the exceptional position in which they placed our country and people. This was not a case in which we could afford to be indifferent, as we do not constitute the whole world."

THE "ACADEMY" FOR AMERICANS.

We had occasion some time ago to refer to the unscrupulous critical spirit which animates a London weekly called the *Academy*, a periodical established and conducted on the principle of bullying itself into notice by copying and exaggerating the most arbitrary features of British journalism. A special effort has been made to push the circulation of the *Academy* in this country, which makes it proper to point out the policy it has adopted toward American as well as English authors. A little American book on botany was republished in London, and attacked by the *Academy* in the most vicious way. The criticism was a string of the grossest misrepresentations, by which the whole character of the book was falsified and libeled. Its author happened to be in London at the time, and wrote a letter to the editor of the *Academy*, exposing the character of its criticism. The editor refused to print it, and the author was compelled to seek another channel to get the true state of the case before the public. The letter declined by the *Academy* was printed by the *Examiner*.

A similar thing has just been done again. Max Müller was allowed to use the *Academy* columns to abuse and misrepresent Prof. Whitney, of Yale College, in matters of philology. The American linguist replied to these assaults in a letter to the *Academy*, which again its editor refused to print, and it found publicity, as before, through the hospitable pages of the *Examiner*. And this difference of fairness between the two journals goes along with other differences which will be of interest to American readers; for, while the *Academy* is characterized by the amount of its pedantic rubbish and scholarly trumpery, suited to the learned drones of Oxford and Cambridge, the *Examiner* addresses itself more to the living questions of the day, and discusses subjects of universal interest, with an ability and independence that may commend it to American readers desiring an English weekly.

LITERARY NOTICES.

THE UNSEEN WORLD, AND OTHER ESSAYS. By JOHN FISKE, M. A. LL. B. Pp. 349. Price $2. J. R. Osgood & Co.

To say that this volume is by the author of the "Outlines of Cosmic Philosophy" will be at once to commend it to a large circle of readers; but as a series of interesting papers on a wide variety of topics, scientific, philosophic, artistic, historical, and critical, it will be commended to many who have not been attracted to the earlier and more solid publication. Most of the articles of the volume will be remembered as they appeared in the periodicals; admirable in style, bold in thought, and rich in scholarly erudition. Mr. Fiske has views of his own which he works out with freedom, and often with great beauty and force of statement.

The volume takes its name from the first two essays, which lately appeared in the *Atlantic Monthly*, and were read with interest by many thoughtful people. They start from the speculations of a recent book entitled "The Unseen Universe," which broke into a somewhat new field of ingenious scientific conjecture, and was read with an eager but rather perplexed curiosity by those who are fond of transcendental inquiries. This work has been already noticed in the MONTHLY, and is chiefly important as an effort by thoroughly disciplined scientific men to arrive at the conception of immortality and a realm of future spiritual life from the scientific point of view. Mr. Fiske is in sympathy with this aspiration, but deals with the problem by his own methods, and perhaps in an abler way than the authors who opened the discussion. We cannot here reproduce his views, which are only to be understood by a careful perusal of the essays in which they are presented.

But, while cordially recommending this volume as a whole, we must except the review of Draper's "History of the Conflict between Religion and Science," which we think somewhat unworthy the author. Mr. Fiske adopts a deprecatory tone in speaking of Draper's books, which is construed by the newspapers into contempt—which jumps with public prejudice, and is quite to be expected from certain quarters; but for which he gives us no satisfactory reasons.

He charges Dr. Draper with superficiality and mental idiosyncrasy, in not understanding Rome; in not appreciating Greece; in hostility to the Catholic Church; in overrating semi-barbarous civilizations, "and above all an undiscriminating admiration for everything, great or small, that has ever worn the garb of Islam, or been associated with the career of the Saracens." But, after indulging in a little sarcasm at Dr. Draper's admiration of the "turbaned sage," Mr. Fiske finds himself compelled to say:

> "Speaking briefly with regard to this matter, we may freely admit that the work done by the Arabs, in scientific inquiry as well as in the making of events, was very considerable. It was a work, too, the value of which is not commonly appreciated in the accounts of European history written for the general reader, and we have no disposition to find fault with Dr. Draper for describing it with enthusiasm. The philosophers of Bagdad and Cordova did excellent service in keeping alive the traditions of Greek physical inquiry at a time when Christian thinkers were too exclusively occupied with transcendental speculations in theology and logic. In some departments, as in chemistry and astronomy, they made original discoveries of considerable value; and if we turn from abstract knowledge to the

arts of life, it cannot be denied that the mediæval Mussulmans had reached a higher plane of material comfort than their Christian contemporaries. In short, the work of all kinds done by these people would furnish the judicious advocate of the claims of the Semitic race with materials for a pleasing and instructive picture."

Very well; these are facts of some importance, but who had brought them out for public appreciation before Dr. Draper published his "History of the Intellectual Development of Europe?" And, although Mr. Fiske may differ from him in regard to the historical import of Arabian science, we fail to see any occasion for the indulgence of sneering and disparagement.

And now in regard to the "Conflict." The theologians of all ilks, who have taken up Dr. Draper's recent book, are agreed that it is a piece of futility because there is really no such conflict as that of which he pretends to have given the history. Messrs. Brownson, Hill, Washburn, Deems, and Co., are vehement in asserting the groundlessness and absurdity of Dr. Draper's assumption; and now, as if he had been sitting under the droppings of the Hippodrome, Mr. Fiske cordially acquiesces in the ardent views of these gentlemen. He says of Dr. Draper: "When he enlarges on the trite story of Galileo and alludes to the more modern quarrel between the Church and geologists, and does this in the belief that he is thereby illustrating an antagonism between Religion and Science, it is obvious that he identifies the cause of the anti-geologists and the persecutors of Galileo with the cause of Religion. The word 'religion' is to him a symbol which stands for unenlightened bigotry or narrow-minded unwillingness to look facts in the face. . . . It is, nevertheless, a very superficial conception, and no book which is vitiated by it can have much philosophic value. . . . Since, then, the scientific innovator does not, either voluntarily or involuntarily, attack religion, it follows that there can be no such 'conflict' as that of which Dr. Draper has undertaken to write the history. The real contest is between one phase of science and another." This will hardly do. Mr. Fiske says that no book vitiated by this superficial conception can have much philosophic value. But, in the "First Principles" of Herbert Spencer, on page 11, we read:

"Of all antagonisms of belief, the oldest, the widest, the most profound, and the most important, is that between religion and science. It commenced when the recognition of the simplest uniformities in surrounding things set a limit to the previous universal fetichism. It shows itself everywhere throughout the domain of human knowledge, affecting men's interpretations alike of the simplest mechanical accidents and of the most complicated events in the histories of nations. It has its roots deep down in the diverse habits of thought of different orders of minds. And the conflicting conceptions of Nature and life which these diverse habits of thought severally generate, influence for good or ill the tone of feeling and the daily conduct. An unceasing battle of opinion like this, which has been carried on throughout all ages, under the banners of religion and science," etc.

Mr. Spencer, of course, holds to the possibility of an ultimate reconciliation between Religion and Science, but he does not commit the folly of denying their past and present antagonism. Dr. Draper has made no attempt to deal with the philosophy of the subject, and he is not to be judged by that standard. Assuming, as Spencer has done, that it is a fact, and a fact of vast significance, he is the first to have given us its history; and, whatever opinion may be entertained regarding the manner of its execution, he had a valid theme, and deals with veritable phenomena. And, had his manner of doing the work been more open to attack, we should probably have heard a good deal less about the baselessness of the antagonism which he has described.

The point of contention is as to what constitutes religion. Dr. Draper was justified in taking the term in its current significance as comprehending the general doctrines and policy of religious organizations. That sects differ, and eat each other up in their denials of dogmas, was nothing to him. And, though they should all agree at last as to what religion is, and discredit the total affirmations of past theology, the historical aspects of the case will remain the same. He was not called upon to settle sectarian disputes, or to find out that denomination which possesses the true faith. Mr. Fiske complains of him for not defining this element of his thesis, and he proceeds to do it himself, as follows: "All animals seek for fullness of life; but in civilized man this craving has acquired a moral significance, and has become a spiritual aspira-

tion; and this emotional tendency, more or less strong in the human race, we call religious feeling or religion." Admirable! but how far accepted? We hope that the agreement of Messrs. Brownson, Hill, Washburn, Deems, Fiske, and Co., in denouncing the groundlessness of the "conflict," will not be construed as implying any agreement among the parties as to what religion is. If these gentlemen will get together and settle the point, an important step will be gained; and THE POPULAR SCIENCE MONTHLY will gladly pay the expenses of a convention of reasonable length for such a purpose, but we stipulate not to foot the bills until they reach an agreement.

A SHORT HISTORY OF NATURAL SCIENCE AND OF THE PROGRESS OF DISCOVERY FROM THE TIME OF THE GREEKS TO THE PRESENT DAY. For the Use of Schools and Young Persons. With Illustrations. Pp. 467. D. Appleton & Co. Price, $2.

WE called attention recently to the influence of the Centennial in stimulating the study of political history, and expressed the hope that the gathering together of the products of art, science, and industry, of all nations, at the Great Exhibition in Philadelphia, would have the effect of promoting the historical study of this class of subjects in American schools. It was pointed out that this line of literature has been greatly neglected, and is so backward that students desiring to attend to it would be much perplexed to find suitable text-books for the purpose. An important and very successful step has, however, been taken to supply this deficiency. The work now published under the above title, considering that it is the first attempt to treat the history of science in a brief and popular way for educational purposes, is of very superior merit. We took it up with doubt, we read it with a growing interest, and cordially recommend it both for general reading and as a school-book. The authoress has made no scientific discoveries; and we question if there are many who have done so who could make so judicious a compend of general scientific history as she has done. But, if she has not made a name as an explorer, she has been a careful student of science, and, having been for many years secretary to the late Sir Charles Lyell, and brought into contact with many of the leading scientific men of the day, she had peculiar opportunities of qualifying herself for the task of writing a popular scientific history. Her style is clear and direct, and her power of explanation we think something quite unusual, while the proportions in which the subjects are treated evince good artistic judgment in the work of book-making. Illustrations are introduced with discretion, to help the text, and brief biographical notices are interspersed which give interest to the course of the narrative, and the exposition of scientific work. The book is, moreover, essentially accurate and trustworthy; and executed with far more faithfulness than is usual in compilations. Miss Buckley's volume ought to be unhesitatingly and extensively adopted in our schools, and kept there until superseded by a better, which we suspect will not be very soon. We do not recommend it to be memorized, or made a matter of formal recitation, so much as for a reading-book to be gone over by suitable classes, with such questions and suggestions as an intelligent teacher can impart. So used, its influence in schools cannot be otherwise than valuable.

DISEASES OF MODERN LIFE. By B. W. RICHARDSON, M. D., F. R. S. Pp. 520. New York: D. Appleton & Co. Price, $2.

WE have already given some excerpts from advance-sheets of this book, which is just issued. Dr. Richardson was led to the treatment of the subject by having first given special attention to the diseases of overworked men. He printed some essays on this topic, and followed them by others on diseases induced by various occupations and by indulgence in the use of alcohol and tobacco. These articles, having undergone revision and considerable extension, make up the present volume. The author carefully abstains from infringing upon the proper art of curing disease which belongs to the medical practitioner, and confines himself mainly to the symptoms and causes of modern maladies, and to hints toward their prevention. While the book will not be without value to physicians, it is carefully adapted to the wants and capacity of general readers. We have simply

to say that this volume is, in a high degree, both interesting and useful. It presents in a pleasant form, and with pointed applications, the sort of information that should be most widely distributed, and abounds in facts and suggestions of importance that cannot be readily obtained elsewhere.

FLORAL DECORATIONS FOR THE DWELLING-HOUSE. A Practical Guide to the Home Arrangement of Plants and Flowers. By ANNIE HASSARD. American edition, revised. With many Illustrations. Pp. 166. New York: Macmillan & Co. Price, $1.50.

THIS little book, written by a person who evidently understands fully the art of floral decoration, will be found helpfully suggestive to all those who wish to make flowers accessory to the attractiveness of their homes.

The author aims, by both illustration and statement, to render the principles underlying her art so plain that any woman may tastefully and successfully decorate her table, adorn her drawing-room, and in some sense, by the use of plants around her windows and balconies, bring to the interior of home not only the beauty but the simple delights of the external garden. The whole subject of table-decoration, including forms of stands and vases, the arrangement of fruit and flowers, the adjustment of these to the light, materials and means for keeping flowers fresh, as well as window-gardening, hanging baskets, grouping of plants, wreaths, crosses, and even button-hole bouquets, find very instructive treatment in this little volume. It is shown how the simplest available materials—ferns, grasses, autumn leaves—no less than the richest products of the florist's art, may serve, in the hands of the skillful manipulator, to produce most graceful effects.

The chromatic principles of grouping are indicated in the following extract:

"In producing harmonious contrasts of colors, it should be remembered that there are only three primary colors—red, blue, and yellow. From these arise what are called the binary or secondary colors, namely, orange, composed of yellow and red; purple, composed of blue and red; and green, composed of yellow and blue. These form contrasting colors to the primary three with which they are in harmonious opposition, as the orange with blue, purple with yellow, and green with red. From the combination with these secondary colors arise three tertiary colors—olive, from purple and green; citron, from green and orange; and russet, from orange and purple. These tertiary colors harmonize with the primaries, as they stand in the relation of neutral tints to them, but are in harmonious opposition to the secondaries from which they are combined. Red, blue, and yellow, harmonize with each other, and they may be placed in juxtaposition, but purple should not be near red or blue, as it is composed of these two colors, the rule being that no primary color should be brought into contact with a secondary of which itself is a component part; nor any secondary color brought into contact with a tertiary color of which it is a component part."

MEMOIR AND CORRESPONDENCE OF CAROLINE HERSCHEL. By Mrs. JOHN HERSCHEL. With Portraits. Pp. 355. New York: D. Appleton & Co. Price, $1.75.

THIS is one of the most fresh and charming volumes that has come from the press in many a day. It is of such unique and special attraction that we have drawn upon it for the materials of two articles in the MONTHLY, which cannot fail to incite the reader to desire the perusal of the whole book. And it will amply repay the most careful reading. Aside from the interest at every step in the life of the remarkable woman who tells her own story in such a vivid and racy way, this biography will have permanent value as connected with the rise of modern sidereal astronomy, and as throwing light upon the characteristics of an illustrious scientific family. Telescopes, new planets, comets, double stars, and nebulæ, are always attractive things to read about, but what engages us most intently with these pages is that they overflow with human nature from beginning to end.

ANALYTICAL PROCESSES; OR, THE PRIMARY PRINCIPLE OF PHILOSOPHY. By WILLIAM I. GILL, A. M. Pp. 483. New York: The Authors' Publishing Company. Price, $2.

THE author of this book made his mark as an acute and independent thinker by the publication, a year or two since, of a volume called "Evolution and Progress." The present volume is the first of a series, each complete in itself, in which a fresh attempt will be made to construct a philosophy. No intimation is given as to what will be its character, the present book being occupied entirely with the foundation,

and with only one element of that—the primary principle of all reasoning. This principle the author finds in the law of non-contradiction, which simply says to system-makers, "Be consistent, or do not contradict yourselves." Obvious as this principle is, we are told that in all ages it has been accepted or rejected alternately according to the exigencies of philosophical speculation, having been nullified by theologians and philosophers from Augustine to Kant. It therefore needs reëlucidation, to which Mr. Gill has devoted his volume. The book gives abundant scope for the exercise of philosophical genius, in which its author is not wanting. Our most eminent metaphysicians, as Drs. McCosh and Anderson, recognize his strong claims as a thinker, and we have no doubt his volume will attract the attention of serious students, and prove a valuable addition to American philosophical literature.

MILITARY MAP OF THE INDIAN TERRITORY. Compiled by First-Lieutenant E. H. RUFFNER, of the Engineers.

THIS valuable map, the preparation of which has occupied Lieutenant Ruffner and Mr. Ado Hunnius, draughtsman and engraver, for some three years, is based on Government and railroad surveys, previously-published maps, military surveys and reconnoissances, etc. The scale is made large enough for marching-purposes, and the topographical details are such as are needed in directing military movements. The task of compiling such a map as this of the Indian Territory is one that involves an enormous amount of labor, and it appears to have been performed with conscientious fidelity by Lieutenant Ruffner. The draughtsman's work is also deserving of great credit. The map is on the scale of 1 : 500,000.

WE have received the initial number of *The Home Scientist*, published at Wadsworth, Ohio. The *Home Scientist* is a monthly, eight-page journal, in quarto, devoted to the diffusion of popular scientific knowledge. This first number, both in its original and in its selected matter, shows evidence of competent editorship. We wish it success. J. A. Clark, publisher. Terms, $1 per annum.

THE POLYTECHNIC REVIEW.—We have received from the publishers the first number of a monthly periodical bearing the above title. In form it is a large quarto of twelve pages, tastefully printed on fine paper. The *Review* is designed to chronicle and illustrate the progress of science as applied to the useful arts, such as engineering in all its branches—civil, mechanical, naval, military, and sanitary; gas and water supply, and sewerage; chemical technology, with particular reference to mining, metallurgy, and manufacturing chemical industries; manufactures in general, and the mechanic arts. That the *Polytechnic Review* will be conducted with energy and ability, the names of the editors, William H. Wall, Ph. D., and Robert Grimshaw, Ph. D., are a sufficient guarantee. Philadelphia: Published by the editors, 119 South Fourth Street. $3 per annum.

PUBLICATIONS RECEIVED.

Geological Survey of Alabama. Report of Progress for 1875. By Eugene A. Smith, Ph. D. Montgomery, Alabama, 1876. Pp. 212.

Memoirs of the Peabody Academy of Science, vol. i., No. iv. Fresh-Water Shell Mounds of the St. John's River, Florida. By Jeffries Wyman, Salem, Massachusetts. Pp. 87.

Statistics of Births, Marriages, and Deaths, in the City of Philadelphia for the Year 1874. Compiled by William H. Ford, M. D. Philadelphia, 1875. Pp. 133.

Experiments with the Alleged New Force. By George M. Beard, A. M., M. D., New York, 1876. Pp. 28.

Report of the Health-Officer of the City of Oakland, California, 1875. By George E. Sherman, M. D. Oakland, 1876. Pp. 32.

Reports of the Trustees and Superintendent of the Butler Hospital for the Insane, Providence, 1876. Pp. 37.

Immobility or Closure of the Jaw, with Report of Cases. By W. F. Westmoreland, M. D. Atlanta, Georgia, 1875. Pp. 10.

The Public-School Question as understood by a Catholic-American Citizen

and by a Liberal American Citizen. By Bishop McQuaid and Francis E. Abbott. Boston, 1876. Pp. 100.

Historical Sketch of the Columbus Public Schools. Columbus, Ohio. Pp. 31.

An Exposition and Defense of Homœopathy. By George Pyborn, M. D. Georgetown, Colorado, 1876. Pp. 36.

Legal Chemistry, A Guide to the Detection of Poisons, Examination of Stains, etc., as applied to Chemical Jurisprudence. By A. Naguet. Translated by J. P. Battershall, Nat. Sc. D., with a Preface by C. F. Chandler, Ph. D., M. D., LL. D. New York: D. Van Nostrand, 1876. Pp. 178. Price, $2.

Life Histories of the Birds of Eastern Pennsylvania. By Thomas G. Gentry. In Two Volumes. Vol. i. Philadelphia, 1876. Pp. 399.

Prehistoric Man. By Daniel Wilson, LL. D., F. R. S. E. In Two Volumes. London: Macmillan & Co., 1826. Pp. 391 and 401. Price, $12.

Report of the Chief Signal-Officer to the Secretary of War for the Year 1875. By Albert J. Meyer. Pp. 475. With numerous Maps.

Exercises in Electrical and Magnetic Measurement. By R. E. Day, M. A. London: Longmans, Green & Co., 1876. Pp. 120.

Daily Bulletin of Weather Reports, Signal Service of the United States Army for April, 1875. Pp. 185.

Man a Spirit only. By R. L. Farnsworth. Pp. 48. St. Paul: *Pioneer Press* print.

Claims of Capital. By William Brown. Pp. 36. Montreal: J. Lovell.

Uses of a Topographical Survey of New York State. By J. T. Gardner. Pp. 14. New York: American Geographical Society.

Product of the Action of Potassium on Ethyl Succinate. By I. Remsen. Pp. 10. From *American Journal of Science.*

Hospital and Private Treatment of Ophthalmia Neonatorum. By S. C. Ayres, M. D. Pp. 8. From *Lancet and Observer.*

Climate in its Sanitary Relations to Medicine. By A. S. Baldwin, M. D. Pp. 14. Jacksonville, Fla.: *Semi-Tropical* print.

Report on Working-Women's Protective Union (1876). Pp. 16. New York: W. W. P. Union.

Astronomische Nachrichten. No. 2,062. Kiel: Königliche Sternwarte.

Training-School for Nurses. Pp. 16. Philadelphia: Grant, Faires & Rodgers print.

Principal Characters of the Dinocerata. By O. C. Marsh. Pp. 6. With Plates. From *American Journal of Science.*

Some Remains of an Extinct Species of Wolf. By J. A. Allen. Pp. 5. From *American Journal of Science.*

Doctrine of Force, and its Bearing upon Theism. By G. N. Duzan, M. D. Pp. 39. Indianapolis: J. G. Doughty print.

Memorial to Congress on the Currency, from the New York Board of Trade. Pp. 13.

Report on Chicago Botanical Garden (1875). Pp. 4.

Report of the Georgia Commissioners of Agriculture (1875). Pp. 180. Atlanta: Estill print.

Polytechnic Review. Vol. i., No. 1. Monthly, $3 per annum. Philadelphia: W. H. Wahl and Robert Grimshaw, proprietors.

MISCELLANY.

Unhealthiness of New Houses. — The unhealthiness of new houses is due to the presence of moisture in their walls. This moisture may be held either mechanically, as by capillary attraction in the bricks, mortar, and plaster; or chemically, in the hydrate of lime. Moisture held mechanically is removable by air and warmth; chemically-held moisture is removed gradually by the action of carbonic acid contained in the air. A writer in the *English Mechanic* suggests the use of a dew-point thermometer as a means of determining whether a house is sufficiently free from moisture to be inhabitable. If we take a reading of this in the open air, in the shade, and protected from wind, we have the actual

atmospheric conditions. If we now transfer the instrument to a room in the house which has been closed for a few hours and without artificial heating, we find the internal conditions. If the dry thermometer is lowered, we may conclude that the walls are cold, and so absorb heat. If the difference between the wet and dry bulbs is lessened, we know the evaporation conditions are lessened; that is, that the internal atmosphere is overcharged with moisture. The two together will prove that the walls are damp, and that the house is disadvantageous to health.

New Tanning Process.—An exhibition was recently given at Havre, France, of Montoison's process of tanning. A variety of skins were experimented on, from the fresh skin of a calf, to the old skins of sheep and goats burnt and hardened by a tropical sun; more time of course was required to unhair the latter than the former. The skins were first soaked in hot water, then they received two coats of a pasty liquid on the inside, and were piled up, inside to inside, to undergo the action of the composition. After the skins had been soaked for a short time, the wool and hair came from them absolutely intact. The manner in which the wool came away from the skin by a touch of the hand created considerable astonishment in the minds of those who witnessed the experiments. In a few seconds the skins were dipped in two special baths to neutralize the unhairing composition, and the afternoon was devoted to tanning experiments, which proved the invention to be a complete success. Experienced tanners, who were present, declared the leather produced to be, to all appearance, fully equal to that produced by the tedious methods in common use.

The Economy of Vegetarianism.—A writer in the *Quarterly Journal of Science* makes a trenchant criticism of the arguments usually employed by vegetarians in support of their system of diet. The author considers the question from the economic, the moral, and the hygienic points of view, but we have not space to give more than an epitome of his remarks on the first of these topics. One hundred acres of good land, say the vegetarians, will support a greater amount of human life if planted with wheat, potatoes, or other crops directly consumed by man, than if laid out in pasture or set with vegetables intended for the food of cattle. This is true, but all land is not *good;* in every country there is abundance of land that is unfit for tillage, and which, nevertheless, yields excellent pasture. Under a vegetarian *régime* such lands would cease to supply the food-market. So too the produce of the forest and moor—game—would cease. More serious still, the waters would no longer contribute their share. It might be said that poor lands could still be used for pasture, and the produce of flocks and herds (wool, butter, cheese, milk) utilized. But if the grazer cannot sell the meat, it would be unprofitable to keep animals, unless he could get, for the products above named, prices a hundredfold higher than he gets now. Besides, the use of milk, butter, and cheese, is inconsistent with vegetarian principles. In a strictly vegetarian country, tallow, hides, and hair, could scarcely be procured. Again, the refuse of the fisheries is rising into importance as a manure fully equal to Peruvian guano. But, if fish might no longer be captured, the supply of this fertilizer would be cut off, unless indeed the destruction of animal life for purposes other than food received an exceptional sanction. Even then the cost of the raw material would be greatly enhanced.

Ancient American Civilization.—In the "Congress of Americanists," held last July at Nancy, France, a very learned paper was read by Prof. Foucaux, of the Collége de France, in favor of the theory that the ancient civilization of America is the work of Buddhist missionaries. The theory was hotly attacked by several of the distinguished men present, among them by Friedrich von Hellwald. The latter compared the story of Huei-shen to that of the sea-serpent. Dr. Hellwald is of the opinion that this theory received its death-blow at the Congress. Two other theories were also very badly damaged, namely, those of a lost continent of Atlantis and of Phœnician settlements in America. M. Léon de Rosny delivered a masterly address on the Maya hieroglyphics. The *Maya* was the sacred

language of the ancient inhabitants of Yucatan, and the monuments of that country bear a number of inscriptions in a hieroglyph which has been only very partially deciphered as yet. M. de Rosny first critically analyzed the attempts at decipherment made by his predecessors, the Abbé Brasseur de Bourbourg and H. de Charencey. The Bishop Diego de Landa first discovered a clew to the meaning of these hieroglyphs; he made out the meaning of seventy-one signs, and the number has been increased to one hundred and thirty-two by De Rosny. The latter has also determined the order in which these signs should be read. As a rule, they run from left to right, but in exceptional cases from right to left. M. Oscar Comettant, of Paris, a musician and composer, attended the Congress expressly for the purpose of reading a deeply interesting paper on "Music in America before its Discovery by Columbus." The author described the Peruvian flute, and, to give the audience an idea of ancient Indian music, had a few simple native Peruvian melodies performed by members of the garrison band. The effect was very pleasing. A comparison of this music with that of China shows that the two are in no respect alike. Here was a new and unexpected argument against the truth of the Huei-shen story. The next meeting of the "Congress of Americanists" will be held in 1877, in the city of Luxembourg.

Climatology of New Zealand.—The two large islands of the New Zealand group, North and South Island, are both very mountainous. In the North Island the mountains occupy about one-tenth of the surface, and in the South nearly four-fifths. The rivers are very numerous, and of large size in proportion to the area of the country; but few of them, however, are navigable. The greatest height of the main range in North Island is 6,000 feet; but in the South Island there are peaks from 10,000 to 14,000 feet in height. The changes of weather and temperature in New Zealand are very sudden; calms and gales, rain and sunshine, heat and cold, alternate so frequently and suddenly as to defy previous calculation, so that there is no uniformly dry or wet season in the year. But, though these changes are sudden and frequent, they are confined within very narrow limits, the extremes of daily temperature varying throughout the year by an average of 20° only, while in Europe, at Rome, and other places of corresponding latitude with New Zealand, the same variation is 30° or more. In respect to temperature, New Zealand may be compared either with England or Italy; but London is 7° colder than the North, and 4° colder than the South Island, and is less moist. Strong winds are prevalent, and particularly in the straits. Rain falls frequently, but seldom in such excessive quantity, or for such long periods, as in Australia. The rainfall, in 1871, was 54½ inches; that of New York City in 1873 was 42½.

Science-Teaching for the Young.—The master of a school for young boys gives an account in *Nature* of his method of teaching his young pupils science. For the purposes of scientific instruction, the pupils are divided into three classes, the lowest of which contains about twenty boys, whose average age is nine years. Class II. is composed of ten boys, of an average age of twelve years, while the first class contains twelve boys, of an average age of twelve and a half years. The time weekly devoted to science-instruction is, for Class III., two lessons in botany of three-quarters of an hour each, and one hour's lesson in physical geography. The pupils are taught to distinguish the parts of a flower, and, by the aid of a chart, to discover the order to which any plant belongs. The second class gives two and a half hours per week to botany. The standard of knowledge aimed at is such as is contained in Prof. Oliver's books, and the boys are expected to be able to find out any given plant in Bentham's "British Flora." The boys in the first class study chemistry, and spend one afternoon of an hour and a half at practical work in the laboratory. Another afternoon is employed in listening to a lecture founded upon a chapter in a text-book of chemistry. The boys, after the lecture, study up its subject-matter in the text-book, so as to be able to answer questions on it at the beginning of the next lesson. The standard aimed at is the power to discover a simple acid and base, and an acquaintance with the text-book.

"These sciences," continues the author, "were chosen less as subjects of study than as instruments of training in order to cultivate the powers of observation, and to encourage a habit of inductive reasoning. If the teaching of science in its early stages is thus regarded more as a means than as an end, there is no child, who has begun to learn anything at all, who may not be taught some branch of it with advantage." The attempt was at first made to teach the children science without making them learn anything by heart. The result was, that they did not know what to do with the facts they had collected, and lost them as fast as they picked them up. "But, since the botany boys have been set to learn the chart by heart, and since the chemistry boys have been using a text-book, the progress made has been far more satisfactory. A young child's reasoning powers are so feeble that he needs to be constantly guided in the use of them, and, before being set to observe, he requires to be furnished with a *cadre* in which to arrange his battalions of facts."

Fishing for Glass-Sponges.—The mode of fishing for the *Euplectella*, or "Venus's Flower-basket," on the coast of Zebu, one of the Philippines, is described as follows in the journal of a member of the Challenger Expedition: "The natives use an ingeniously-contrived instrument in taking the sponges. Two long strips of bamboo meet at an angle of 45°, and are fixed in that position by an elaborate system of stays of bamboo, which are attached to a piece of wood running back from the angle, between the two arms or wings of the machine. The piece of wood is weighted with stones, and a line is attached to it, so that the machine is pulled along on the bottom, with the angle in advance, and the two wings sloping backward. The outer edge of each of the bamboo rods is armed with between thirty and forty large fish-hooks, with their barbs set forward. The *regederas*, as the Spaniards call the euplectellas, are found at a depth of about a hundred fathoms. The Indian lets down the machine with a strong fine line of Manila hemp, and pulls it slowly over the ground. Every now and then he feels a slight tug, and at the end of an hour or so he pulls it in, with usually from five to ten *regederas* on the hooks. Euplectella has a very different appearance, under these circumstances, from the cones of glassy network so well known under that name. Its silver beard is clogged with the dark-gray mud in which it lives buried to about one-third of its height, and the network of the remainder of the tube is covered with a pall of yellowish sarcode.

Congress of German Anthropologists.—The Congress of Anthropologists held its sessions for 1875 in Munich, in the early part of August. The president, Prof. Virchow, reviewed the history of the German Anthropological Society since its origin, sixteen years ago. Prof. Zittel called the attention of the delegates to the collection of prehistoric relics on exhibition in one of the halls of the Odeon. The collection represented the ancient Kelto-Germanic period of Bavarian history, and was the result of the joint efforts of various historical societies, aided by the Government and by private collectors. "Of Tertiary man," said Prof. Zittel, "no trace is found in Bavaria, any more than in the rest of Germany, nor have we any human memorials from the period of the preglacial Diluvium. Even the Cavern and the Stone age yield but few human remains. Burying-places furnish both dolichocephalous and brachycephalous crania—the latter belonging to Southern Bavaria, the former to the Allemans and Franks. We must not deny to the Bavarian of to-day a Germanic origin on account of his brachycephaly, for even the Frisians are brachycephalic also. In manners and customs Bavaria is as German as any other portion of Germany, and it is not to be dropped out of the German organism. Its post is that of guardian of the southern marches."

The Weddas of Ceylon.—A paper by Mr. B. F. Hartshorne, read at the British Association, gives some interesting particulars of the social condition and habits of the Weddas of Ceylon. The Weddas depend for their subsistence on bows and arrows, and pass their lives in the vast forests of the country without any habitation, and without even the rudest attempt at culti-

vating the soil. No flint or stone implements are to be found among them, and they produce a flame by rubbing two sticks together. Their intellectual capacity is so small, that they are unable to count or to discriminate colors. They are almost destitute of the religious sentiment, as well as of an appreciation of personal cleanliness, for they habitually eschew ablutions. They abhor theft and lying. But, perhaps the most remarkable trait in the character of the Weddas is the apparent absence of a faculty which is held to be peculiar to the human race—that of laughter. It is stated that they regard the expression of mirth by others with surprise and disgust, and that no Wedda has ever been known to laugh.

Lettuce as Food for Silkworms.—A writer in *Das Ausland* states that, in the summer of 1873, a few silkworms, belonging to his children, were fed with lettuce for some time after being hatched, mulberry-leaves not being obtainable. The caterpillars ate the lettuce ravenously, but, when they were about half-grown, a supply of mulberry-leaves was procured, and this constituted their food for the rest of the season. The moths in due time spun their cocoons as usual, and the next spring the author himself determined to feed the silkworms only on lettuce. The young brood devoured the lettuce in great quantities, care being taken to leave no moisture on the surface of the leaves. The insects grew and went through their metamorphoses in the usual manner; a few only died, and they from carelessness in not wiping the leaves dry. The cocoons were of good quality, and the author intended to exhibit some of them at the Royal Agricultural Hall in Stuttgart. Time alone can determine whether silkworms will degenerate on being fed on lettuce. However this may be, the subject is one that is worthy of investigation.

Dredging for Amber.—According to an official report from Memel, Germany, an establishment has been organized for obtaining amber by dredging in the Kurische Haff, near the village of Schwarzorts, situated about twelve miles south of Memel. It has been known for many years that amber existed in the soil of this place, from the fact that the dredger employed by the Government for clearing away the shallow spots near Schwarzorts, which impeded navigation, brought up pieces of amber, which were duly appropriated by the workmen, and at the time no particular attention was paid to the matter. Some time afterward, however, some speculators associated, and made an offer to the Government not only to do the dredging wherever required at their own expense, but to pay a daily rent, provided the amber which they might find should become their property. This proposal was accepted, and the rent fixed at 15 thalers, and later at 25 thalers, for each working day. The dredging was begun with four machines worked by men, and one worked by horses. Judging from the extended business transactions in this matter, its results must have been extremely profitable. At present, the work is carried on with eighteen steam-dredges and two tug-boats, the whole managed by about 1,000 laborers.

Temperature of Germination.—It is generally supposed that the seeds of plants do not germinate at a temperature lower than 4° or 5° Cent. (40° Fahr.), but certain experiments made by Uloth, and published in the German botanical magazine, *Flora*, would seem to show that this opinion is erroneous. In Dr. Uloth's experiments the seeds of *Acer platanoides* and of *Triticum* germinated at a temperature not exceeding zero C. (32° Fahr.). In the winters of 1871–'72 and 1872–'73, he made the following experiments: He took two boxes and in each had a certain depth of water frozen into a block of ice. In these blocks he made furrows four millimetres deep, in which he sowed seeds of various plants, which were the same for the two boxes. He now covered the boxes with a plate of ice, and stored them away in two separate ice-houses. He then partly filled two boxes with soil, in which he sowed the same kinds of seeds. These boxes he also covered with plates of ice, and stored them in the same ice-houses with the others. Care was taken to have a good thickness of ice (over four feet) surrounding the boxes on every side, so as to provide against any elevation of the temperature. The boxes were placed in the ice-houses in January,

1872, at a temperature of —8° C., and they were taken out on May 15th. In 1873, they were placed in the ice-houses in February, the temperature being —5° C., examined on March 25th, and removed on May 15th. The kinds of seed sown were twenty-five in number. On March 25th, four had germinated, viz., *Lepidium ruderale*, *L. sativum*, *Sinapis alba* and *Brassica napus*, all Cruciferæ. On May 15th, besides the foregoing, the following seeds had germinated: *Arabis alpina*, *Æthionema saxatile*, *Brassica nigra*, *Petroselinum sativum*, *Cannabis sativa*, *Ervum lens*, *Pisum sativum*, *Avena sativa*, *Secale cereale*, *Hordeum vulgare*, *Triticum vulgare*.

Hence it appears that the seed of Cruciferæ and of Gramineæ freely germinate at the temperature of zero C. Of the seeds named above, about an equal number germinated in ice and in earth. The radicles had penetrated the blocks of ice. Those seeds which had not germinated lay rotten on the surface of the ice or of the soil.

Transformation of Species.—An instance of transformation of species is recorded as follows in the *Zeitschrift für Wissenschaftliche Zoologie*. There are some salt-marshes near Odessa, which in 1871 contained numbers of *Artemia salina*, a minute crustacean, also known as the brine-worm. At that time, owing to the rupture of a dike, the quantity of salt in the pond was very small, the water marking 8° in the Baumé areometer. The dikes were repaired, and concentration then proceeded rapidly until, in September, 1875, the water marked 25°. As the salt was increased the *Artemia salina* was modified from generation to generation, so that, by the end of 1874, several individuals had no caudal lobes (*see* figure of *A. salina* in No. 20 of the MONTHLY, December, 1873), and they presented all the specific characters of *Artemia Mulhauseni*. The changes observed from year to year are minutely described. They appeared especially in the caudal part, and were accompanied by diminution of size. These observations were confirmed by experiments made on *Artemia* kept in water of various degrees of softness. In the inverse experiment from a greater to a less softness, *A. Mulhauseni* returned to the form of *A. salina*. As the saltness increased or decreased, there was an increase of diminution of the surfaces of the bronchiæ. The writer of the article further gives reasons for thinking that the genus *Artemia* is only a degraded form of *Bronchipus*, degraded through the influence of the medium.

Clothing the Young. — "Hygiene of Dress" is the subject of a series of articles in the *Sanitary Record*. The author's remarks concerning the proper clothing of infants and children are judicious. "Warmth," he says, "is the first requisite for infants, who are very susceptible to cold. The clothing of the infant should be both light and warm. Its purpose is to protect the infant from chills, or rather to prevent too great a loss of heat. It should be ample enough to prevent any pressure on the blood-vessels, which would impede the circulation and hinder the free development of the members. It should be especially easy over the chest, in order to insure the free play of the lungs and heart, and should be equally ample around the stomach and the intestines, in order not to interfere with digestion. The sleeves should be wide, in order that the garment may be easily put on, and to favor the circulation of the blood in the arteries and veins of the arms and legs. The robe should be long enough to preserve the infant from cold, but not so long as to be a burden. The head should not be covered. A cap often tends to favor congestions; sometimes, too, it compresses the head, and certain cerebral affections have been, apparently with good reason, referred to this cause alone.

An Automatic Light-Registering Machine. —Mr. Crookes has made an ingenious application of his radiometer to meteorological purposes. In our present meteorological records we note variations in heat, rainfall, atmospheric pressure, etc., but light, the most important influence, has been neglected hitherto, for the want of a machine for automatically registering its variations. Mr. Crookes has arranged the arms of his radiometer so that they carry round a small magnet suspended beneath them. The amount of light falling on the pith-balls at the extremities of the radiometer arms determines the rate

of rotation. Near the magnet, attached to the rotating arms, is suspended another magnet, which oscillates as the attached magnet presents alternately its north and south poles. This oscillation makes and breaks an electric circuit, which, by a wire of any required length, is connected with a recording Morse machine moved by clockwork. Each revolution of the rotating pith-balls is thus recorded by a punch of the Morse on a strip of paper, and so a register is kept of the amount of light falling at any place.

A Mountain of Granite.—The "Stone Mountain" of De Kalb County, Georgia, is described in the *American Journal of Science* by Mr. E. Hillyer. It is a solid, bald mass of granite, from 1,500 to 2,000 feet in height. The northeast side is perpendicular, unbroken, and smooth; the northwest side is inclined so as to be of easy ascent; while the west and southwest are so steep as to be barely accessible. On the inclined surface the rock breaks off in layers, a few inches to several feet thick, which structure may be due to shrinking in cooling, and to atmospheric influences, together with solar heat. The rock is perfectly homogeneous, with no trace of stratification—a pure whitish granite. There is no doubt that below the surface lamination a piece could be quarried out a quarter of a mile in length, if man could command the means. This granite exists over a wide region of country, and is much used for building-purposes.

Rattlesnakes and their Bites.—In the course of some notes on the rattlesnake, published in *Forest and Stream*, Dr. J. W. Bailey, of Albany, asserts that this serpent is the most sluggish of the snake family. It never strikes unless in self-defense, excepting just before and after its winter sleep. Of course, the rattlesnake's idea of self-defense is rather broad. Thus, if a person step upon it by the purest accident the snake will make no allowance, but strikes the intruder on the spot. To strike, however, it must be in close coil, with its head erect. It is capable of springing only a little more than half its length, unless it be lying on an inclined plane; then, by supporting itself entirely on its tail, it can spring much farther. Hogs attack the rattlesnake with impunity, the effect of the poison being probably neutralized by a thick layer of adipose tissue. Dr. Bailey is able to contradict, from his own experience, the statement that serpents do not move about at night; he has often, when riding by moonlight seen them gliding through the grass. The author says that, when the venom of a serpent has entered the circulation, all remedies are unavailing. He has seen a freshly-killed chicken split open and applied to the wound, with good results. In such cases the flesh of the chicken turns green and putrid where it comes in contact with the virus. The most certain remedy, however, is whiskey or brandy used in large quantities —say a quart—immediately. Intoxication is not exhibited until the poison has been counteracted. Sweet-oil, taken in doses of several ounces, is also effectual. Sportsmen camping in Texas are accustomed, after pitching their tent, to stretch around it a hair lariat. The short hairs irritate the snake's belly as he attempts to cross the lariat, and he retreats.

Cause of Monstrosities.—In the course of a discussion of the subject of "monstrosities," in the Detroit Academy of Medicine, Prof. Armor, of the Long Island Medical College, who was present, presented some ingenious views, which may be briefly stated as follows: Monstrosity is commonly referred to "arrest of development" or to "abnormal development." But what is the true cause? Prof. Armor answers: 1. Something deficient or abnormal in the generative matter from which the fœtus is developed. This generative matter he looked upon as *representative;* there is not a tissue, structure, or form, that is not represented in it, so that deviation from the normal type may be impressed at the very instant of conception. The next point was the faithful transmission of *acquired* structural peculiarities, when once fully established. Finally, it was suggested that the discussion of this subject bears directly upon the great question of evolution: the strongest and fittest survive; weak parts of the organism atrophy and die—they cease to be seminally represented. 2. The

next cause of monstrosities mentioned was such as operated directly on the *fœtus in utero*. The generative matter may be perfect and fully representative, but certain morbid influences may act directly on the fœtus. Dr. Armor instanced the experiments made in producing malformations by submitting hens' eggs to various mechanical influences during incubation. In conclusion, he held that all causes of malformation would come under one of two heads: They are either *generative* or *mechanical*—sometimes one operating, sometimes the other, sometimes both.

Habitat of the Crocodile.—Till recently the two American species of crocodile, described by Cuvier, have been supposed to be confined to South America and the West Indies. In 1870 Prof. Wyman identified a skull from Florida as belonging to Cuvier's species, *Crocodilus acutus*. Mr. William T. Hornaday now describes in the *American Naturalist* two specimens—male and female—of the *Crocodilus acutus* which he captured last year in the vicinity of Biscayne Bay, on the southeast coast of Florida. The male was fourteen feet in length, and his girth at a point midway between fore and hind legs was five feet two inches. His teeth were large and blunt; his head rugose and knotty, with armor-plates very large and rough. On dissection it was found that during life he had sustained serious bodily injuries, probably in battle. Three of his teeth were shattered; the tibia and fibula of the right hind-leg had been broken in the middle and again united, also one of the metatarsal bones of the same limb; the tail had been docked, and two of the vertebræ had grown together solidly.

The female measured ten feet eight inches. Her head was regular in outline, comparatively smooth, with white, regular, and sharp plates, even in surface and contour, and colors very marked. The entire under-surface of both specimens was pale-yellow, shading gradually darker up the sides with fine irregular streaks and spots of black. The general appearance of the female was decidedly yellowish, while the back and tail of the male showed an almost entire absence of yellow, the prevailing color being a leaden, lustreless black. While in Florida the author saw the skulls or other remains of three other crocodiles. He observes that all the specimens were taken in water that is brackish about half the time.

Effects of Strain on the Magnetism of Soft Iron.—The following account of experiments made by Sir William Thomson, with a view to ascertain the effects of stress upon the magnetism of soft iron, we take from the *Telegraphic Journal*. Wires of steel and of soft iron, about twenty feet long, were suspended from the roof of the physical laboratory of Glasgow University. An electro-magnetic helix was placed around a few inches of each of the wires, so that the latter could be magnetized when an electric current was passed through the former, the induced current thus produced in a second helix outside the first being indicated by a second galvanometer. With steel wire, the magnetism diminished when weights were attached to the wire, and increased when they were taken off; but with "special" soft-iron wire (wire almost as soft as lead), the magnetism was increased when weights were put on, and diminished when they were taken off. Afterward he discarded the electrical apparatus; and, by suspending a piece of soft wire near the magnetometer, consisting of a needle a small fraction of a grain in weight, with a reflecting mirror attached, the wire was magnetized inductively, simply by the magnetism of the earth, and changes in its magnetism were made by applying weights and strains, the changes being then indicated by the magnetometer.

The Origin of Astronomy.—Like that of many other sciences and arts, the origin of astronomy has been ascribed to various nations of antiquity, and it is very doubtful if any one of these can lay exclusive claim to the credit of having been its founder. The succession of day and night and of the seasons, the phases of the moon, and the motions of the heavenly bodies, must have enlisted the attention of man from the earliest times and in every clime. The result would naturally be a more or less perfect system of astronomy. Some nations, no doubt, from one cause or another, culti-

vated this science with more success than others, and among these the Assyrians, Babylonians, or Chaldeans, are preëminent. The records of their observations were adopted by the Greeks, and through the latter were transmitted to the Romans. Thus our modern astronomy is really traceable back to the plains of Babylonia. The question arises, Of what race were the founders of Chaldean astronomy? This subject is considered by A. H. Sayce, who, in a communication to *Nature*, says that they were not Semites, but a people who are now generally termed Accadians, and who spoke an agglutinative language. "They had come from the mountains of Elam or Susiana, on the east, bringing with them the rudiments of writing and civilization. They found a cognate race already settled in Chaldea, and in conjunction with the latter they built the great cities of Babylonia, whose ruins still attest their power and antiquity. Somewhere between 3000 and 4000 B. C., the Semites entered the country from the east, and gradually contrived to conquer the whole of it. It is probable the conquest was completed about 2000 B. C. At all events Accadian became a dead language some two or three centuries later, but, as the Semitic invaders owed almost all the civilization they possessed to their more polished predecessors, it remained the language of literature, like Latin in the middle ages, down to the last days of the Assyrian Empire."

Sounds produced by blowing into a Flame. — Some noteworthy observations have been made by Decharme on the production of sounds by blowing into a flame through a tube. He is of opinion that the air acts rather chemically than mechanically. The sounds, according to him, result from small explosions by the combination of the oxygen of the air with the hydrogen or carbon of the flame, in imperfect combustion. For the sound to occur, the presence of air, or of an inert gas mixed with oxygen, seems necessary. In one of M. Decharme's experiments the white flame from a Bunsen burner, with the lateral apertures closed, gave a very strong sound when blown into with a tube; whereas the blue flame, produced when the apertures are open, gave a very weak one, or none at all. Carbonic acid alone, or nitrogen, or oxygen, or chlorine, blown into a flame of illuminating gas, gave little or no sound; protoxide of nitrogen gave a sound that was weak, but more acute than that obtained from air.

Exploration of Victoria Cave.—Dr. Tiddeman read a report on the exploration of the Victoria Cave, Settle, during the year 1874–'75. The report assigns to the preglacial or the glacial age the lower deposits of this cave, which contain early Pleistocene animal remains associated with a human fibula. The animal bones were nearly all mere fragments, though one was perfect; they represent bears, oxen, deer, goats or sheep, elephants, swans, etc. Attention was called in the report to the great distance of time which separated that age from our own. In the cave Roman times were separated from our own day by deposits sometimes less than a foot thick, but nowhere by more than two feet of talus, the chips which time detached from the cliffs above. The Neolithic age, which antiquaries knew was a considerable time before the Roman occupation, is represented in some places at a depth of four or five feet beneath the Roman layer, but at others it runs into it. Then come nine feet of talus without a record of any living thing. Judging by the shallowness of the Roman layer, this must represent an enormous interval of time. Next come the bowlders, the inscribed records of the Glacial period. They must represent a long series of climatic changes during which the ice was waxing and waning, advancing and moving back over the mouth of the cave. Then there is a break in the continuity of the deposits, the bowlders lying on the edges of the older beds, which shows that time was given for changes to take place to allow the district to cool down from a warmth suitable to the hippopotamus and become a fitting pasture for the reindeer. It was in that warm period that the man lived and died whose fibula occurs among the bones in the cave.

Methods of preserving Fresh Meat.—So numerous are the processes devised in modern times for the preservation of food, that

a simple catalogue of them would occupy several pages of this magazine. In so far as the preservation of vegetables and of certain fruits is concerned a very fair measure of success has undoubtedly been achieved; but with flesh-meat the case is different. We propose to describe here a few of the chief methods adopted for preserving meats, following for the most part a writer upon this subject in the *Journal of the Society of Arts*. These methods may all be reduced under the four heads of Desiccation, Refrigeration, Use of Chemical Antiseptics, and Application of Heat. Desiccation or drying has been practised from the earliest times. Charqui, or jerked beef, is an example of fairly successful preservation, but it is immensely inferior to fresh meat. Some years ago the food committee of the London Society of Arts reported favorably upon some specimens of "powdered beef" from Queensland; but the article has been unable to win its way to public favor. The reason of this no doubt is, that animal matter preserved by desiccation loses its flavor and becomes tough and indigestible, the fat becomes rancid, and in damp weather the whole turns mouldy and sour. These difficulties are to some extent obviated by mixing absorbent substances with fatty food, as in "pemmican," where sugar and spice are mixed with dry powdered meat. Meat-biscuit is made on a similar principle. Tellier, of Paris, adopts the following method: He first exhausts the air from a close vessel containing the meat, then fills it with carbonic-acid gas, again exhausts and again fills with the same gas. In this way the air is almost entirely removed. He then absorbs the carbonic acid by the use of a concentrated solution of potash, by which a very near approach to a vacuum is produced. The meat is removed from the vessel after three days, and may be kept sound without further trouble, but it will have lost 20 per cent. of its weight.

The keeping of meat by refrigeration is practised on a small scale in every household. The same thing was done on a large scale at Melbourne in 1872, when a large quantity of meat was kept for six weeks perfectly fresh in an ice-chamber. In the following year an attempt was made to ship from Australia to England meat kept fresh by the same method, but the experiment failed. Better success has attended later shipments of meat from Canada to London, and from Texas to New Orleans. The progress made in ice-making machines is such as to inspire great hopes of success in preserving meat by cold.

Among chemical antiseptics common salt of course holds a place. Many patents have been taken out for the employment of sulphur-fumes (sulphurous acid). Bisulphite of lime is very efficacious for the temporary preservation of meat, and has been practically tested with favorable results. Our readers need not be reminded of what is claimed for salicylic acid. Among other chemical agents employed for this purpose we may mention acetate of potash and chloralum.

The expulsion of atmospheric air from vessels containing meat, by means of heat, is certainly the most successful method of preservation yet adopted. Many difficult processes are in use, but the main principle —expulsion of air by heat—is the same in all. They all, too, agree in this, that they render the meat comparatively insipid.

NOTES.

THE subject of iterated nesting by birds being under discussion in *Forest and Stream*, Dr. Charles C. Abbott contributes to that journal the following list of birds which he has himself observed nesting twice in summer: 1. Usually breeding twice—robin, catbird, bluebird, house-wren, yellow warbler, English sparrow, bay-winged bunting, chipping-sparrow, song-sparrow, orchard oriole; 2. Occasionally breeding twice—white-breasted nuthatch, scarlet tanager, yellow-bird, chewink, Baltimore oriole, purple grakle.

THE American Metrological Society has, through its president, memorialized Congress for the preparation of coins, of metrical weight and uniform fineness, and for the passage of laws and conclusion of treaties whereby such coins shall become legal tender, according to their weight.

A CRUCIAL experiment was recently made at Sunderland, England, on a fire-proof house. One of the rooms was filled with tar-barrels, wood, and other combustible material, and, when the door was shut, the mass was set on fire. It simply burnt itself out, without apparently affecting the condition of the adjoining rooms or the stability of the house itself. The building material was a concrete of cement and fibre

bound together by strings of iron and wire. This becomes a sort of stone-cloth, available for floors and doors, as well as walls and ceilings, so that no wood whatever need be used.

A SMALL pike caught by Dr. Charles C. Abbott, of Trenton, New Jersey, seemed to be unusually corpulent, so the fish was dissected. It was found to contain a large mud-minnow; within the minnow was a pike about two inches long, and within the pike the remains of another mud-minnow!

THE action of sundry drugs on the liver has been experimentally studied by Drs. Rutherford and Vignal, the result going to show that podophylline, aloes, and colchicum, are powerful hepatic stimulants. The same property, but in an inferior degree, is possessed by rhubarb, senna, taraxacum, and scammony. Croton-oil appears to have but little action on the liver. In three cases out of four calomel had no action on the liver, and in the fourth the secretion of bile was slightly increased.

THE *Lancet* publishes a list of British physicians deceased last year at an advanced age. There are nineteen names in the list, and the sum of their ages amounts to 1,617 years, showing an average age of eighty-five years. The greatest age attained by any of the deceased was ninety-six years, and three had reached that term. The lowest was seventy-six years, at which age two of the deceased ended their career.

THE *Monthly Weather Review* of the Signal-Office records the following phenomena for December, 1875, namely: Dandelions in bloom at Brownsville, Pennsylvania, on the 23d; 24th, pinks and hyacinths in bloom at Brookhaven, Mississippi; 25th, peach-trees in bloom at New Orleans; 31st, peach and cherry buds swelling at Litchfield, Michigan, and on the same day roses in bloom at Green Springs, Alabama.

As mentioned in the Notes of the November number, the Abbé Moigno, of Paris, has published several papers by Tyndall, Huxley, Du Bois-Reymond, and others, accompanying them with refutations of their authors' freethinking arguments. The good abbé doubtless meant well, but the Roman "Congregation of the Index" finds in his book more poison than antidote, and accordingly forbids it to be circulated.

EARTHQUAKE-SHOCKS are stated in the *Monthly Weather Review* to have been felt on December 3d at Carson City, Nevada (slight); 13th, at Maricopa Wells, Arizona; 21st, at Santa Barbara, California; 22d, at Fortress Monroe, Virginia; also at New Market, Indiana; Greensboro, North Carolina; Petersburg, Virginia; and other points in Virginia, Maryland, and North Carolina.

A COMMITTEE of the Boston Society of Civil Engineers has drafted a form of petition to be addressed to Congress, asking for the establishment of the metrical system of weights and measures in this country. This system is now in use in all European countries except England, Norway, Sweden, Russia, and Turkey. It has also been adopted in Mexico and the various states of South America.

THE Royal College of Surgeons, of England, having been advised by eminent counsel that the terms of their charter require them to admit women as candidates for their diploma, have announced that they are now ready to admit women to the examinations, on the same conditions as men.

THE repugnance of the Chinese to railroads is based upon an article of their religion—ancestor-worship. Constructors of railroads pay no respect to ancient burying-places, but run their lines right through them, thus disturbing the repose of the dead. This disregard of the sacredness of the last resting-place of the departed grievously scandalizes the devout Chinaman.

CYNODRAKON MAJOR is the name proposed by Prof. Richard Owen for a reptile having some points of mammalian resemblance, some fossil bones of which have been found in the late palæozoic or early mesozoic formation of South Africa. Prof. Owen thinks he recognizes in these fossils some indications of retrogression rather than progression in descent. A problem is here presented for which, in Owen's opinion, neither the Lamarckian nor the Darwinian theories offer any answer.

WE learn from the *American Naturalist* that a summer School of Biology will be held in the Peabody Museum at Salem, Massachusetts, beginning July 7th, and continuing six weeks. Special attention will be given to marine botany and zoölogy. Mr. J Robinson will be instructor in botany, with C. H. Higbee as assistant. A. S. Packard, Jr., with the assistance of J. S. Kingsley and S. E. Cassino, will give instruction in zoölogy. Special instruction in microscopy by Rev. E. C. Bolles. The number of pupils is limited to fifteen.

FURTHER experiments with salicylic acid, made by Feser and Friedberger, show that it may be administered for a long time, in small doses, to domestic animals, without injurious effects to digestion, nutrition, or general health. But, given to a dog in the proportion of one gramme to five kilogrammes of the animal's weight, salicylic acid causes paralysis of the extremities and disorder of the respiration and circulation. Death from strong doses of the acid results from paralysis of the respiration.

THE Normal (Illinois) "School of Natural History" will open on July 25th, continuing in session till August 25th. The course of study embraces comparative anatomy of vertebrates; comparative anatomy of invertebrates; analytical zoölogy; analytical entomology; botany. In the list of instructors are the names of B. G. Wilder, Cyrus Thomas, and J. A. Sewall. Fuller information given by S. A. Forbes, Normal, Illinois.

IN the *American Journal of Science* for February, Prof. J. D. Dana corrects an error which for many years has circulated in geographies, gazetteers, and similar works. This error consists in representing the West and East Rocks near New Haven as being the termination of the Green and White Mountains respectively. "The fact is," writes Prof. Dana, "that East Rock is but a short appendage to the system of trap-dikes of the Connecticut Valley, and West Rock, a southern portion of the same system. The Green Mountains," he adds, "consist of metamorphic rocks, and are not younger than Silurian. But the trap ridges of the Connecticut Valley belong to the valley, and are of Jurassic origin."

A STATION for agricultural experiments has been established at the Wesleyan University, Middletown, by the State of Connecticut. Dr. Atwater, Professor of Chemistry in the university is the director, and Dr. W. C. Tilden, with two assistants, is the acting chemist. The State appropriation being insufficient to defray all the expenses of the station, the proprietors of the *American Agriculturist* have agreed to make up the deficiency.

THE twin-steamship Castalia, which during four months of last year daily made voyages between Dover and Calais, appears to have given satisfaction in every respect, save speed. Arrangements have now been made by the Channel Steamship Company for the building of a large twin-steamship, which, uniting all the advantages of the Castalia with such improvements as experience has suggested, will have a speed of not less than fourteen knots an hour.

A WONDERFUL case of recovery from a gunshot-wound was that of the late Commander Sanders of the British Navy, who died last February, at the age of ninety-one years. In 1803 he was shot in the head, the bullet passing clear through from ear to eye. He was kindly cared for by the surgeon of the French ship which he was attempting to "cut out" when he received the wound. At the end of five years' detention as a prisoner of war, he went back to England sound and well, with the exception of the loss of an eye.

THE relative strength of various substances is stated as follows in the *Scientific American:* A rod ¼ inch in diameter, of the best steel, will sustain, before breaking, 9,000 lbs.; soft steel, 7,000 lbs.; iron wire, 6,000 lbs.; good iron, 4,000 lbs.; inferior bar-iron, 2,000 lbs.; cast-iron, 1,000 to 3,000 lbs.; copper wire, 3,000 lbs.; silver, 2,000 lbs.; gold, 2,500 lbs.; tin, 300 lbs.; cast-zinc, 160 lbs.; cast-lead, 50 lbs.; milled lead, 200 lbs.; box or locust wood, 1,200 lbs.; toughest ash, 1,000 lbs.; elm, 800 lbs.; beech, cedar, white-oak, pitch-pine, 600 lbs.; chestnut and maple, 650 lbs.; poplar, 400 lbs.

A NEW variety of bronze, containing manganese, and known as "manganese bronze," has lately been introduced in England. It is said to be very valuable for all kinds of small work wherein gun-metal is now used, and it is capable of being forged like iron.

DURING a visitation of extreme cold weather in the vicinity of Carson River, the quicksilver pump in the Eureka mill ceased to perform its proper functions; the machinery of the pump continued to work, but no quicksilver was raised. On examination, the mercury in the tank was found to be frozen solid.

THE British Geological Society has this year awarded to Prof. T. H. Huxley its Wollaston Medal. Prof. Huxley has also been elected a Corresponding Member of the Danish Academy of Sciences. The Royal Academy of Rome has conferred a similar honor upon Mr. Herbert Spencer, having elected him a Corresponding Fellow.

PROF. D. S. JORDAN, of Indianapolis, will conduct a summer School of Science, during the coming season, in the mountains of East Tennessee. The members of the school will collect specimens of the birds, reptiles, fishes, insects, and plants, of that region.

IN a cave near Thayngen, Switzerland, Conrad Merck has discovered a quantity of animal remains, consisting of bones of the reindeer, cave-lion, mammoth, woolly-haired rhinoceros, urus, glutton, and other species. Relics of human habitation have also been found in great abundance—such as flint-flakes, implements of reindeer-horn, and several well-executed engravings on bone, horn, and lignite.

A WRITER in the *Gardener's Monthly* states that, when properly cured, the kernel of the American walnut is white and delicious, with a delicate flavor hardly surpassed by any nut. The nuts should be gathered as soon as they are ripe, and not allowed to remain in the hull. They should then be dried quickly.

BENJAMIN THOMPSON (COUNT RUMFORD).